The Institute of Physics

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The Bulletin is published by The Institute of Physics for circulation to its members.

Notices to Members

Annual Dinner

Members are reminded that the Annual Dinner of the Institute will be held at the Park Lane Hotel, Piccadilly, London, on Tuesday, May 5, 1959. The two principal guests and speakers will be Sir Keith Murray and Dr. J. B. Conant. Sir Keith Murray, Chairman of the University Grants Committee since 1953, has had a most distinguished career and for seven years was Rector of Lincoln College, Oxford. Dr. Conant, one of the most renowned of American scientists, has been President of Harvard University and Ambassador of the United States of America to the Federal German Republic. Forms of application for tickets will be circulated later ; members are reminded that they may bring as many guests as they wish.

Remission of Income Tax on Members' Subscriptions

In the June issue of the *Bulletin* attention was drawn to the provisions of the 1958 Finance Bill whereby subscriptions to approved professional bodies would be allowed to rank for tax relief under Schedule E. The Institute has now been approved by the Commissioners of Inland Revenue " for the purposes of Section 16 of the Finance Act, 1958." This means that the whole of the annual subscription paid by a member who qualifies for relief under that section will be allowable as a deduction from his emoluments assessable to income tax under Schedule E.

The official ruling is as follows :—

" Commencing with the year to April 5, 1959, a member who is an office holder or employee is entitled to a deduction from the amount of his emoluments assessable to income tax under Schedule E of the whole of his annual subscription to the society provided that—

(*a*) the subscription is defrayed out of the emoluments of the office or employment, and,

(*b*) the activities of the society so far as they are directed to all or any of the following objects—(i) the advancement or spreading of knowledge (whether generally or among

persons belonging to the same or similar professions or occupying the same or similar positions) ; (ii) the maintenance or improvement of standards of conduct and competence among the members of any profession ; (iii) the indemnification or protection of members of any profession against claims in respect of liabilities incurred by them in the exercise of their profession ;

are relevant to the office or employment, that is to say, the performance of duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned."

A Member who wishes to claim this relief should apply to his or her tax office immediately for form P358 on which to make a claim for adjustment of P.A.Y.E. coding.

London and Home Counties Branch : Address by the President

Sir George Thomson is to lecture to the London and Home Counties Branch of the Institute on January 14. The meeting is to be held at the Royal Institution, Albemarle Street, W.1, at 5.30 p.m. The President's subject is "Controlled Thermonuclear Reactions." Admission to the lecture is by ticket only, but tickets are available to all who are interested, whether members of the Institute or not ; they may be obtained on application to the Deputy Secretary.

Graduateship Examination

The 1959 Graduateship Examination will be held from June 1 to 5 in London and such provincial and overseas centres as are required. Intending candidates are reminded that formal application for admission to the examination must be made before December 31 next ; the appropriate form of application may be obtained from the Deputy Secretary.

Revision of Banker's Order

Those members who pay by banker's order and have not returned their revised orders for 1959 are asked to do so as soon as possible.

Journals at Members' Rate

The Institute's Journals for 1959 will continue to be sent to those members already subscribing, unless notice of cancellation is received by the Secretary before the end of this year.

Applied Spectroscopy Group : Additional Meeting

The Applied Spectroscopy Group of the Institute has arranged a meeting for Wednesday, December 3, at 5 p.m., at the Institution of Electrical Engineers, Savoy Place, W.C.2. Professor S. L. Mandelstam of the Lebedev Physical Institute (Moscow Academy of Science) will lecture on "A Review of Developments in Spectroscopy in the U.S.S.R." The meeting is open to all interested and tickets are not required.

Radiofrequency Spectroscopy Meeting

A joint meeting of the British Radiofrequency Spectroscopy Colloquium and the Groupement AMPERE will be held in the Physics Department, Queen Mary College (University of London), Mile End Road, London, E.1, on April 1, 2 and 3, 1959, on "Molecular and Atomic Motions in Solids and Liquids by Radiofrequency Methods." Information and application forms may be obtained from Dr. J. G. Powles (*Fellow*) at the address given above.

Symposium on Nuclear Fuel Cycles

Places are still available for members and visitors who wish to attend the Institute's symposium on "Nuclear Fuel Cycles" which is to be held on January 22 and 23, 1959, in London. The program is as follows :—

Session 1 : (*a*) "Long-term reactivity changes"
(*b*) "Theory of once-through fuel cycles"
(*c*) "Perturbations due to fuel cycles"
Session 2 : "Optimization of fuel cycles for nuclear power stations"
Session 3 : "Fuel cycle operational problems"

The papers deal with the applied physics aspects of the fuel cycles which form the basis of the immediate nuclear power program.

Application forms for tickets to attend the symposium may be obtained from the Secretary of the Institute and should be returned immediately.

Vol. 9, November, 1958

The Possibility of Controlled Thermonuclear Reactions—Impressions of the Geneva Conference

By J. S. FORREST, M.A., D.Sc., M.I.E.E., F.Inst.P.
(Director, Central Electricity Research Laboratories, Leatherhead)

THE following notes are based on information submitted to the Second United Nations International Conference on the Peaceful Uses of Atomic Energy held at Geneva on September 1-13, 1958. A broad picture of the thermonuclear research in progress in various countries was obtained, not only from the papers presented, but also from informal discussions at the Scientific Exhibition.

INTRODUCTION

It has been known for a long time, as the result of experiments made in the Cavendish Laboratory and elsewhere from 1932 onwards, that fusion reactions could be achieved between particles in the laboratory by bombarding targets containing light elements with light nuclei, but there appears to be no possibility of obtaining a useful release of energy by such a process. Another approach to a fusion reaction is to heat the gas to such a high temperature that the nuclei will acquire sufficient energy to overcome their Coulomb repulsion. The following reactions between deuterium nuclei, or between deuterium and tritium nuclei, seem to offer the best chances of success :

$$D + D = He^3 + n + 3{\cdot}3 \text{ MeV}$$
$$D + D = T + p + 4{\cdot}0 \text{ MeV}$$
$$D + T = He^4 + n + 17{\cdot}6 \text{ MeV}$$

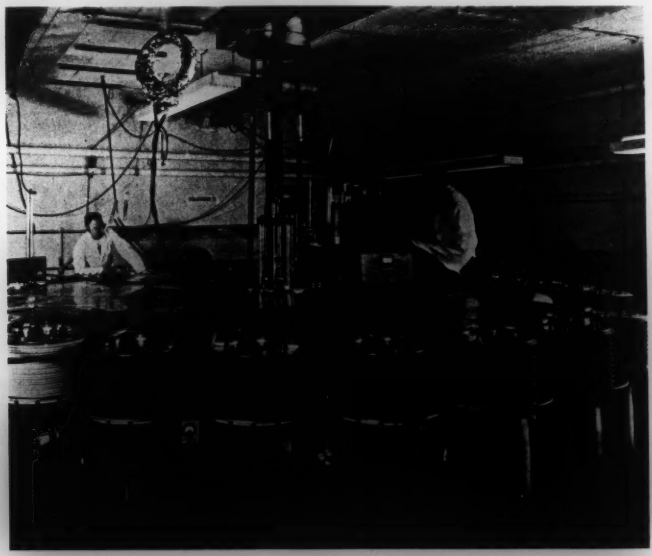

Fig. 1. *"Columbus II" at Los Alamos.*

Fig. 2. "*Stellerator B-3*" *at Princeton.*

For a useful release of energy, the first two reactions involve temperatures of hundreds of millions of degrees, and the D – T reaction tens of millions, but for technical reasons most of the experimental work is being done with deuterium. Research on fusing light nuclei by means of very high temperatures was started by Sir George Thomson in 1947, and in various countries work commenced in the 1950's with the object of achieving fusion between deuterium nuclei by passing very high energy electrical discharges through the gas. A spectacular demonstration of an uncontrolled thermonuclear reaction was given when the first hydrogen bomb was exploded in 1952. Increased interest in achieving fusion in a gas discharge with the possibility of the controlled release of energy was aroused when Kurchatov described Russian work early in 1956 at Harwell. He showed that heavy current pinch discharges in deuterium give rise to the emission of neutrons. This led to an optimistic phase ; it was considered that a gas discharge in a torus would provide the obvious solution to the problem and that it was only necessary to keep the discharge away from the walls and inject enough energy for a reasonable time in order to achieve a true thermonuclear self-sustaining reaction. The publication of the Harwell " Zeta " results (and those from other laboratories) followed in August, 1957, with the announcement that neutrons had been produced and temperatures of the order of 5,000,000°C achieved, the implication being that the neutrons were from a true fusion reaction.

Then a period of more sober appraisal followed when it was realized that the neutrons could be produced in many ways, and that it was unlikely that the observed neutron yield was from a fusion reaction. Moreover there was considerable doubt about the actual value of the temperature in the discharge, and in fact about the whole mechanism of discharge plasmas.

The present position is that it is accepted that to achieve a bulk fusion reaction, and especially to get a useful power output, is not likely to be easy, and that it will be necessary to attack the problem on a wide front both theoretically and experimentally. The aim of the researches now in progress in many countries is not to try to get a

practical result quickly but rather to obtain basic knowledge on the physics of plasmas, using a very wide range of experimental techniques in parallel with theoretical investigations.

THEORETICAL INVESTIGATIONS

The crucial question as to the origin of the neutrons observed in many discharge experiments is not now considered to be of such immediate importance. It is realized that if genuine thermonuclear neutrons are produced they can be easily recognized because : (*a*) their number will be consistent with the magnetic field pressure ; (*b*) they must be isotropic ; (*c*) their energy spread must not be extensive ; and (*d*) they will be produced in such numbers that no mechanism other than a thermonuclear reaction could explain their occurrence. Accordingly, the opinion voiced by Artsimovich (U.S.S.R.)[1] was shared by many ; namely that it was profitless to argue as to the exact origin of the comparatively small numbers of neutrons observed by many workers.

The theoretical work on the behaviour of plasmas in a magnetic field is summarized by Alfven (Sweden)[2]. The stability of the plasma is studied by the methods of magneto-hydrodynamics, a subject relating to the behaviour of an electrically conducting fluid in a magnetic field, which has previously been of importance only in astrophysics. It is shown that various types of plasma waves may be set up, such as longitudinal electrostatic oscillations ; transverse (Alfven) waves ; and hydromagnetic (shock) waves. More detailed accounts are given in papers by Rosenbluth (U.S.A.)[3], Tayler (U.K.)[4], Allen (U.K.)[5], Grad (U.S.A.)[6], and Kruskal (U.S.A.)[7].

Although the theoretical work is providing some guidance on possible methods of confining plasma, and heating it to a high temperature by magnetic compression or by shock waves, there are many discrepancies between the theoretical results and the performance of actual experimental devices. It is often difficult to apply the theories to practical arrangements, and the experimental machines tend to be based on a mixture of theoretical principles and empirical design.

A serious difficulty which has recently been encountered by many workers[8, 9, 12] is that a major loss of energy is occurring in the plasma which reduces its electrical conductivity and hence its temperature. This energy loss cannot be explained at present. It may be due to instability of the plasma, with a consequent loss of energy to the walls of the discharge tube, or to plasma oscillations (wavelength approximately 0·1 mm) and the production of " runaway " electrons in large numbers. A loss of 200 kA of 3 to 5 kV electrons was quoted by Colgate (U.S.A.)[10] !

EXPERIMENTAL METHODS

In order to achieve a fusion reaction, it is necessary to create a plasma, heat it to thermonuclear temperatures and confine it for long enough to obtain a useful energy output. The gas may be heated by ohmic discharge, by magnetic (adiabatic) pumping, or by hydromagnetic shock waves. The plasma may be created and heated in situ, or it may be injected into further chambers for heating. Practically all conceivable combinations of these processes are being tried in a very wide variety of experimental machines. Most of these machines produce neutrons in bursts of 10^6–10^8 neutrons per pulse. An attempt is made below to classify the various types of machine and describe the main lines of investigation now in progress.

Pinch Effect Machines

In the simplest form of pinch discharge, the axial current in the discharge produces its own magnetic field which contracts the discharge to a narrow column. This discharge is unstable, however, and various devices, such as additional magnetic fields and conducting sheaths, have to be employed to stabilize it.

The pinch discharge may be linear ; an example of this is the A.W.R.E. (Aldermaston) equipment " Maggi " in which a 45 kJ low-inductance condenser bank is used, capable of producing a peak current on short-circuit of 4,000,000 A.[11] Other examples of linear pinch equipments are " Columbus II " (Fig. 1) and " Columbus S4 " at Los Alamos.[9] There are also variants of the linear pinch, such as the " screw dynamic " pinch, and a cylindrical sheet discharge (Triax), both being investigated at the University of California Radiation Laboratory.[10] The French C.E.A. in conjunction with E.D.F. have also made experiments with a linear pinch discharge tube.[12]

A still favoured form of pinch discharge tube is the torus, although this does not now occupy the predominating position that it did a few months ago. The A.E.A. " Zeta " and the A.E.I. " Sceptre " are well-known examples. A Russian equipment on similar lines to " Zeta " is known as " Alpha " (Fig. 3) ; this has a 4.5 metre diameter torus. The French C.E.A. are also experimenting with a torus (" Equator 1 "),[13] and a considerable amount of work has been done at Los Alamos with toroidal discharges, the latest

version being the " Perhapsatron S4," an aluminium torus with a quartz liner supplied from a 90 kJ capacitor bank. Work on toroidal discharges is also being carried out in Sweden at Uppsala.[14]

An apparatus known as " Astron " with some similarity to the pinch machines is being studied at the University of California Radiation Laboratory.[15] It is based on the use of a sheath of relativistic electrons to confine the plasma.

Stellarators

The " Stellarator " is the name given to a group of discharge devices being investigated at Princeton, which take the general form of a twisted torus, such as a figure-of-eight, but differ from the pinch device in that external magnetic fields produced by coils encircling the discharge tube are used to confine the plasma (Fig. 2).[16] In addition, separate coils are used for ohmic heating and magnetic compression. A further difference is that the device is intended for steady-state and not for pulsed operation.

Mirror Machines

The essential feature of the mirror machine, of which there are many varieties, is that externally generated magnetic fields are used to form a " magnetic bottle " to confine the plasma. The plasma may be injected into the machine and heated by magnetic compression, and the compression may take place in several stages. A large effort is being put into mirror machines (" Pyrotrons ") at the University of California Radiation Laboratory.[17] In U.S.S.R.[1] a large mirror machine (" Ogra ") has been built with a diameter of 1·4 metres and a length of 20 metres (Fig. 4). Another machine which uses magnetic compression to heat the plasma is " Scylla "[9] ; it is being studied at Los Alamos where a plasma acceleration machine for injecting a jet of plasma into vacuo is also being developed.

An interesting variant of the mirror machine is the direct-current experiment (D.C.X.) in which confinement of the plasma is obtained by a d.c. magnetic mirror field, but a carbon arc is used to dissociate a stream of injected deuterium ions at the energy of 600 kV.[18] The atomic ions produced are trapped in a closed orbit in the magnetic field and form a ring of high temperature plasma. Still another approach is the Ion Magnetron of the University of California Radiation Laboratory, in which the magnetron principle is applied to the confinement of ions as well as electrons.

Homopolar Machines

In the homopolar machine being studied at the University of California Radiation Laboratory,

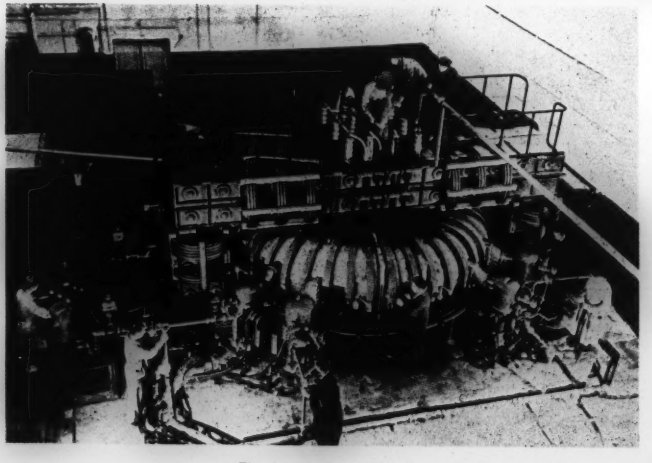

Fig. 3. *U.S.S.R. " Alpha "*

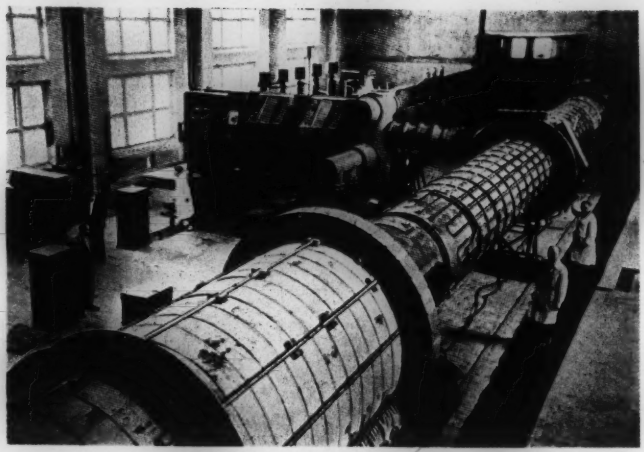

Fig. 4. *U.S.S.R. "Ogra"*

the possibility of achieving thermonuclear temperatures by means of a rotating plasma is being explored.[19] The rotation is produced by the application of an axial magnetic field and a radial electric field, as in a homopolar machine. An interesting feature of this machine is that it behaves as a hydromagnetic capacitor with a dielectric constant of more than 10^6, and it appears possible that a new and compact system of electrical energy storage based on rotating plasmas might be developed. Another machine called "Ixion" for research on rotating plasmas is being studied at Los Alamos.[9]

Other Methods of Plasma Confinement

A possible method of confining high temperature plasma is by means of non-uniform cusp-shaped magnetic fields. Consideration is being given by the Americans to such a "picket fence" design,[20] and the Russians are apparently devoting quite a lot of effort to the study of devices using guard electrodes and magnetic traps with corrugated fields.[1, 21]

TIME REQUIRED TO ACHIEVE THERMONUCLEAR POWER

The general attitude at the Conference regarding the rate of development of thermonuclear power was extremely cautious. The consensus of opinion was that in ten years we would know if the development of thermonuclear power was a practical possibility, and at least a further ten years would be required for the necessary engineering developments, which would undoubtedly involve formidable problems.

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Correspondence

The Scientific Typewriter

It might be useful to start some discussion among all types of scientists about standardizing the keyboard of typewriters for use by secretaries of professional scientists. The typewriter was developed for business use, and other professions have made the best use they could of the large pool of typists available, skilled in handling the single standard keyboard. It seems to me that there are now a sufficient number of scientists about, writing and re-writing reports, employing a sufficient fraction of the pool of typists to justify effort to provide them with a standard scientific keyboard. So far, there appear to be two solutions open to the person who wants his mathematical or Greek symbols typed in.

(*a*) To decide himself what he is most likely to use during his life, to buy a standard typewriter and have the keys changed to suit his particular whims. Then he has the choice of learning to type —quite a time consuming effort if he is to achieve reasonable efficiency in the long run, and involving the penalty of doing it all himself—or of putting his typewriter under a succession of assistants, with the obvious penalty of little or no financial recompense from his firm if the assistants are inefficient typists. The financial aspects might be met, if he has achieved sufficient standing, by turning each typewriter he comes across to his own pattern. Each fresh assistant will come to the machine unversed in its peculiarities, however, with consequent loss in efficiency.

(*b*) To accept reports which have been done on the multi-type-unit system. This has pretty poor results on the 2nd . . . . . nth copies, unless extreme care is taken, which means low efficiency and high cost.

A third solution seems possible if sufficient interest can be generated on a national level, resulting in the setting up of a working committee to decide on a standard scientific keyboard.

J. D. Hill (*Graduate*)

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Vol. 9, November, 1958

The Recruitment of Women as Physicists —the Problem in the Schools*

By Mrs. C. E. ARREGGER, M.Sc., F.Inst.P.
(*Hilger and Watts Ltd.*)

To-day we hear continually that there is an urgent and ever-growing need for scientists and technologists in research, in teaching and in industry. The government has set high targets for the output of trained people and is spending large sums of money on the expansion of facilities for training, weighted heavily on the side of technology. The young people who will take advantage of these increased facilities and who will eventually be the scientists and technologists are now in the schools. Our only source of supply of scientists for the next generation are the boys and girls whose futures are being moulded by the parents and teachers of to-day and whose own personal aspirations are influenced by what they hear from those parents and teachers and to some extent by other outside influences such as television, radio, newspapers and the careers of their slightly senior acquaintances. If we want a greater proportion of the more able of these boys and girls to become physicists, we are doing well now to consider the problem in the schools from every possible angle.

Women form a very small proportion of existing professional physicists. It is not easy to find out what this proportion is. We know that approximately 16 per cent of the science students in the universities are women, that is one in six but, of these, about half take biological subjects and about equal numbers take chemistry and physics so we are left with about one quarter of the total number of these women taking physics. The success ratio is, I gather, about the same for women as men. The proportion of women members of the Institute of Physics is, as we know, very small and, judging by the minute sprinkling of names in the regular lists of elections to membership, cannot be increasing. Some idea of the proportion is given by the response to the Salary Survey in 1956 when, out of a total of 2,539 replies, only 48 were from women—that is 1 in 53, less than 2 per cent.

Why are there so few women physicists? We have gone past the age when it was regarded as axiomatic that women were incapable of the kind of reasoning required for scientific work.

We know that there have been a few famous women scientists and that, at present, we have some outstanding women and a fair sprinkling of able ones. We know that in other countries, notably Russia, although we may tire of repeated comparisons, the women are being outstandingly successful and that the entry to the Technicums is equal for males and females in spite of the very keen open competition for places. We cannot acknowledge that the relative ability is higher there than in our own country. In contrast we must realize that in industry in general, the proportion of women to men is 1 in 3 and many of these women are employed in the engineering industry. The skills and mechanical abilities for quite intricate though nominally unskilled work is there. To find an answer to our question we must consider the many different problems related to the schools, the universities, the attitude of industry and to social patterns and habits. I will deal first with the problem in the schools in detail and then touch briefly on the others.

For girls the first bias is set early in life, even in pre-school years, when children, boys and girls, have very similar physical and mental qualities and like to play with the same toys, but girls are given domestic, feminine toys and prevented from using mechanical or, so-called, dangerous toys while boys are expected to want to hammer nails and to be attracted to mechnical objects. A little later the hobbies are also differentiated and boys, who very often are most addicted to cookery are shooed out of the kitchen while girls are not allowed near their father's tool box. (Incidentally, this lack of experience with tools is a nuisance to a professional women scientist all her life, because at all stages, unless she insists, she is protected by her male colleagues from acquiring practice in contrast, again, to her unskilled sisters who soon are expected to pick up the tricks of their trade.)

Learning through hobbies with a scientific bias in the early formative years plays a great part in the future choice of specialized studies because, in contrast perhaps to the rather dull initial lessons in scientific subjects, the child can achieve something concrete and, by creating something real, like a model aeroplane or a simple radio set, can develop interests for future achievements. Girls, as a rule, are not encouraged, or even are positively discouraged from following these

* A lecture given to the conference of the Education Group and South-Western Branch in Bristol on April 10, 1958.

more creative mechanical hobbies. Also there is some point in remembering that girls, who are more often expected to give help in the home, have usually less free time than boys.

In the junior schools boys and girls are taught together with, again, this splitting up to some extent where scientific or mechanical subjects are expected to interest boys more than girls, although some enterprising schools have I hear, had remarkable success when they included girls in the woodwork and metalwork classes and boys in domestic science.

The poor quality of the teaching of arithmetic in many primary schools causes much trouble when the children pass up into the secondary schools but this should affect the boys and girls equally, since they learn in mixed classes. The results in the eleven-plus examination show that there is little to choose between the average boy and girl in intelligence and ability as far as it is shown by this examination. Science is not taught systematically in the junior schools under local education authorities although general scientific studies are followed to some extent and this varies from school to school, but the private prep. schools have rarely any facilities at all for teaching science.

Those children who will eventually proceed to a professional career will at the age of eleven-plus enter a secondary grammar school or at about this age go to a public or private school with a similar type of curriculum. At this stage there is, in most cases, a complete split between the boys and the girls into separate schools while even in co-educational secondary grammar schools opportunities to study scientific subjects are not necessarily equal for boys and girls. It is recognized that in a boys' grammar school there should be the organization for a strong science side with physics as the chief science subject and in the public schools this recognition is rapidly growing but, in girls' schools, the conditions are very uneven and provision of laboratory facilities and a satisfactory share of the time-table for science is frequently lacking or completely inadequate and, where science is taught, biology and chemistry are usually given preference to physics and the numbers taking these various subjects at "O" and "A" level of the General Certificate of Education bear this out.

The approach to physical science teaching is still regarded in many girls' schools as an innovation, although this is changing to some extent, and it is often only begun really systematically at too late an age. At an early age science lessons can be fun and simple experiments can awaken interest but, if this elementary work is left until the age of thirteen or fourteen, it is boring and a girl will naturally give her interest and attention to those other subjects in which she has reached a level more suited to her own stage of mental development. I know of the enthusiasm of classes of small girls in practical physics lessons and I myself advocate quite a different approach during the first year of teaching. I would start physical optics before geometrical, start the study of sound by listening to an orchestra and heat with a study of a steam engine and would introduce ideas on nuclear physics ; then, when the imagination is fired with the scope and magnificence of the subject, the elementary principles can be taught, because they are shown to be necessary in order to understand the final problems presented. It would be fascinating and not impossible for the educationists to rewrite the text-books backwards and if part of the general history lessons throughout the school included information about the growth of science and the progress of scientific men as they lived in various centuries and in different countries instead of dealing quite so much with battles long ago, all the children would have an appreciation of the real contribution science has made and is making to our modern civilization. Even if these seemingly revolutionary ideas are considered for the moment unpractical I would still stress that elementary physics could be shorn of much of the initial drudgery by more inspired teaching at the early stages and by rigorous pruning of non-essentials.

The "broadening" element in those who organized school curricula some years ago introduced the subject called General Science which still, in spite of much adverse comment, survives in many time-tables, particularly in girls' schools.

I agree that it is a very good subject to teach in junior schools and to upper classes of those who are not science specialists, but it is a very bad foundation for a scientific education, giving a muddled beginning and being, perforce, presented by teachers who themselves are specialists in one or other of the sciences and who, therefore, must somehow acquire some superficial information about the subjects which they have never studied systematically. Since the majority of women science teachers are biologists the presentation of physics suffers most in this scheme.

Owing to time-table difficulties and to lack of accommodation, many girls' schools offer physics with chemistry and this, while a definite improvement on general science still means a lack of time to study each subject effectively and is a handicap to a child who wishes to study physics or chemistry

seriously in the Sixth form although it does leave more time for other subjects.

It cannot be too strongly emphasized that it is essential that any girl who wishes to specialize in science in later years should have a good general education including English and a modern language and possibly Latin. A scientist should be able to think clearly and to express himself or herself clearly and must have facility with words and too early specialization in either science or arts subjects is to be deprecated.

There seems to be a lot of muddled thinking in girls' schools as to what constitutes a good, balanced educational scheme. Where the sciences are taught early in the school curriculum with sufficient time and trouble devoted to them to make the effort really worth while, this is labelled " too early specialization " while a curriculum with little or no science is erroneously called " a good general education." It is time that, apart from providing the necessary early foundation for science specialists, the good general education for all thinking women as well as men—and we are dealing with the top 20 per cent creamed off by the eleven-plus examination—should contain a basic introduction to the physical sciences in an age where science, for better or for worse, has so much effect on our lives.

These women of the future can have more influence for sanity if they can combine their acknowledged humanitarian influence with a feeling of confidence that they know what they are talking about when dealing with social, economic and political problems involving science.

There is one great problem which has to be faced in any discussion on the teaching of physics to girls, and that is the great difficulty found by so many otherwise able girls in comprehending mathematics. This problem is at present exercising many peoples' minds. Since mathematics is an essential tool for a physicist, we should consider this question here. As stated earlier, the eleven-plus examinations indicate very little difference between boys and girls in arithmetic but when the more abstract concepts of mathematics are introduced some paralysis of the mind or complete lack of acceptance seems to occur much more frequently with girls than with boys. In a four stream girls' school, it is possible to get an excellent " A " stream in mathematics but after this there is a great drop in competence and the lowest streams are often quite unable even to struggle on. I have met this seeming blind-spot in girls of good average ability. It would seem to be a psychological problem worthy of tackling and some kind of application of work-study in the teaching of mathematics seems to be an urgent necessity. Actually very full and very practical recommendations on the teaching of mathematics were made by the United Nations International Bureau of Education at their 19th Conference held in Geneva in 1956 in which there is an explicit statement that psychologically there is no reason to believe that girls are less apt than boys in the study of mathematics. It may be that in the initial stages, the transition from the practical to the abstract is too sudden. It is held by some that mathematical abstractions could be introduced earlier and more gradually with better results. Since, without mathematics, so many doors are completely closed to a student, it is well worth while to lay this spectre.

Too many girls are allowed to drop mathematics, at the age of 13 or 14 who could later make up, in part, for lost ground. It would seem that girls in mixed schools who should get equal opportunities with the boys should not suffer this trouble but, in discussion with headmasters, I have learned that at approximately age 13 many girls slip behind, become disheartened and ask to drop the subject. The low quality of teaching of mathematics in the girls' schools if it exists, cannot be the answer in this case. Recently it was stated that less than half of the girls entering teachers' training colleges had passed in mathematics at the General Certificate of Education " O " level and less than 4 per cent took mathematics as a special subject. These are the primary school teachers of the future, so without some extraordinary effort things will not improve.

Given success in the efforts to encourage more girls to take science in the lower forms of the grammar school we could expect a broader stream of potential physicists to come up through the girls' schools to the Ordinary level of G.C.E. girls of good ability with a firm grounding in mathematics and science but not without a good general background of education. At this stage we look for people who can express themselves and who are developing critical faculties and a breadth of interest and the inquisitiveness necessary for good Sixth form work. Then comes the time when, in present circumstances, specialization is inevitable.

Here at Sixth form level, in the large majority of cases, the girl is at a disadvantage. Up to this point she will probably not have been able to study any applied mathematics and, if she has offered physics with chemistry as one subject at " O " level, she has to work phenomally hard to prepare herself for the advanced level examination in these individual subjects together with mathe-

matics in two or even three years. Indeed the passing or failing of this examination is coming to be regarded rather as an indication of the capabilities of the teachers rather than a criterion of the pupil's ability. Time for broader general education is cut down to a minimum and these formative and valuable years are given over to a grind.

The operating factor in this is the high standard of university entrance requirements. Surely better material for the universities could be prepared by broadening the Sixth form courses and leaving the extreme specialization to the first year at the university. The failure rate of 30 per cent of entrants to physics departments does not seem to indicate that the present arrangements for selection are adequate. The recent innovation in some universities of a Special Entry course for able students who have taken Arts subjects in "A" level and have mathematics at "O" level and who wish to read science at the university is, to my mind, a step in the right direction. It could be particularly valuable for those able girls with a scientific bent who have not had the opportunities at school to receive adequate instruction in the sciences.

The picture I have painted is gloomy and it is not to be wondered at that from the point of view of academic preparation, comparatively few girls actually reach a high enough standard for acceptance into an honours physics course, but those few who do are not always given the encouragement one would expect in this age when so much is talked of the shortage of scientists. To my certain knowledge within the last four years, capable girls have been discouraged by three different university physics departments from entering ; two were told that the only jobs available for women physicists would be teaching and since they did not want to teach but to enter industry they took other subjects and were very disappointed, and the third who had had brilliant examination results throughout her school and public examinations, was warned about the failure rate in the physics department and urged to think again, so she took medicine. On the other hand, I have heard from two or three other university professors that any capable girl would be welcome.

Some criticism of the quality of University teaching has been raised from time to time and I would also point out that this might weigh more heavily against girls in their first year at the university than against boys because of the more protected kind of life and the closer supervision of studies in a girls' school. Nobody wishes to encourage spoon-feeding in a university but some more attention could be paid to the choice of first year lecturers for their skill at presenting their subject as well as for their aptitude for research work. The universities have the choice of all the talent in the schools and there should not be the need for such a large percentage of first-year failures as exists at present among both sexes.

From my remarks up to now it can be gathered that only the most capable and most determined young women will reach the final stages of their degree course in physics and it is not to be wondered at that at least some of those who stay the course are outstanding and finally successful.

The technical colleges provide another avenue of approach for the professional physicist but even fewer girls take advantage of this than of a university course. It would seem that few headmistresses are sufficiently aware of the increasing opportunities available for courses leading to degrees or to other professional qualifications at the technical colleges through either full-time or part-time courses. One technical college principal pointed out to me that, for girls accustomed to the type of teaching in a girls' school, the transition to a technical college was not so difficult as to a university and that the good practical girl who might not aim at academic honours of the highest order could obtain very satisfactory training and could do well. For girls who are keen to enter industry, a college based sandwich course leading to a Higher National Certificate or Diploma in Technology would seem to be an ideal method of training. Few firms, even now, are willing to sponsor girls for works-based sandwich courses but in a college-based course, where available, the college will arrange for the practical training and help can be obtained from the Local Education Authority towards the fees. I have heard of one or two such girl students who made such a good impression during their periods of practical works training that they were offered permanent positions by the firms concerned. Possibly this could be used as a means of convincing industry of the value of women technologists. Again the technical college training by part-time day release during employment is rarely used by girls.

It would seem also that few girls are given sufficient information about the professional bodies and about the advisability of working their way up to the recognized professional qualifications. This may be because so few women physics teachers are on the register of the Institute

of Physics. It may be of great help in the recruitment of girls and women as physicists if the Institute of Physics took steps to make itself and its objects better known in the girls' schools.

The educational problems are many if the tempo of production of women physicists is to be accelerated but other problems have to be faced which are not purely educational. If girls are to be encouraged to take up careers as physicists they must know first what a physicist is and what she does and the prospect must be encouraging and also the parents must have this information. Do we do enough to make our activities known ? How many average parents, particularly mothers, have ever heard of physics except in connection with atom bombs and maybe nuclear power plants ? They know about medicine and auxiliary medical services, maybe about chemists who work in the food and drug industries but the work of physicists, as such, is shrouded in mystery. It would be well worth while to get much more information in a palatable form into the hands of teachers, girls and parents.

Another problem in girls' schools is the great loss of potential talent due to early leaving. It has been stated in the Ministry of Education report on Early Leaving, published in 1954 that there was enough academic ability to justify an increase in the numbers staying on in the Sixth form of boys by one half and of girls by two thirds. Numerically about 5,000 boys and 5,000 girls could well have completed advanced courses and of these 2,900 boys and 1,300 girls were potential scientists. The reasons suggested were many but the parents' attitude was among the most important since, where circumstances are difficult, greater importance is usually attached to the sons' education than the daughters'. This penalizes particularly those girls from middle class and professional homes most hit by crippling taxation and lack of help with university fees and maintenance because of the low-pitched means test. These are just the girls who would be of the intelligence level for higher studies. Other reasons for early leaving were the attractions of well-paid but dead-end jobs and some criticisms were levelled at employers who enticed those girls with good results in G.C.E. mathematics and science papers at " O " level, to positions as junior technicians in industrial and research laboratories.

Another real difficulty, as we all know, is the shortage of science teachers, and particularly of physics teachers, in girls' schools. Any measure to increase the number of girls taking physics and so to form a broader stream of science pupils coming up, the girls' schools will result in an increase in the number of science teachers. The Ministry of Education Report on Early Leaving, mentioned above, pointed out that, in the sample of girls' schools examined, nearly one third of the science Sixth forms contained less than five girls and more than half contained less than 10. It would seem that with the same number of teachers more pupils could receive instruction even now.

Lack of equipment is also a serious problem. Many girls' schools have laboratories suitable for biological work but quite unsuitable for teaching physics. Some girls' schools, 82 in all, received building or equipment grants from the Industrial Fund for the Advancement of Scientific Education in Schools whose assessors stated in their report that inevitably they were a long way behind the level of the boys' schools and many were far below the minimum standard for which help would be considered effective.

Much more still needs to be done in this direction. Laboratory assistants are now being provided to a much larger extent than formerly but, even where the need is recognized, the shortage of trained people makes it difficult to fill the positions.

One more problem, and this is very important, is the uncertainty about the scientific careers available to the girls after training. Parents are unwilling for their daughters to take scientific subjects at school and highly specialized training afterwards unless they feel that interesting and well-paid careers are reasonably assured. Here the attitude of industry is to be deplored. We know that women with degrees in physics can get positions and that there are more openings available than can be filled but we also know that there is a reluctance among many industrial employers to come out into the open and express a demand for girls and women and to open their training schemes at all levels to girls. The advertisements ask for men and careers for men are painted in glowing colours in the leaflets so profusely distributed but women and girls are not mentioned or, if so, only in a small subsidiary note. How can young girls know that there are opportunities ? If there is really an urgent need for more workers in this field there is surely a need for a more realistic attitude to the use of the untapped potential among women and girls. Further, when women are employed, the best use should be made of their services in jobs which use their capacities to the best advntage and opportunities for promotion should depend only on ability. It is true that women marry, we would not wish

it to be otherwise, but one in three of the married women in this country are working and with the changing pattern of a woman's life due to early marriage and child-raising, there is, and will be to an increasing extent in the future, a large proportion of useful working life left after the children are grown. Even now, women with professional training are more and more returning to their careers later in life.

Finally, what about the attitudes and preferences of the girls themselves? I think it is true to say that a smaller proportion of girls than boys are career-minded. Head mistresses find that girls make up their minds about their preferences for a type of career later than boys and, in general, do not aim so high. This can easily be understood because it follows a long tradition of either purely domestic ambitions or, later, of the acceptance of stop-gap jobs to use up the time before marriage. Much encouragement should be given to able girls to think about the possibilities of a career and to go forward to obtain qualifications and to take their places in the professions.

To sum up, I have suggested that in the present conditions of shortage of physicists, efforts should be made to make the fullest use of women. The necessary training and encouragement should start early in life, perhaps even in pre-school years but at least during school life girls should be given equal training with boys and in the secondary school a systematic science teaching should start early and that great attention should be given to the teaching of mathematics. Too early specialization—either in Arts or Science—should be avoided but physical science should be for all part of a good general education. The aim should be to produce a broader stream of science pupils coming up through the schools to provide potential teachers and workers in research and industry. The overloading of Sixth form pupils was commented on and the doubtful qulity of first year teaching at the university. Attention was called to the neglect of opportunities for training in the technical colleges and lack of information about professional bodies. The problems of early leaving, shortage of teachers and lack of laboratory facilities were mentioned also the lack of information about careers in physics and the discouraging attitude of industry Finally a word was said about the lack of career-mindedness of the girls themselves.

I do not think that these problems are insurmountable. Very great strides have been made since that time, only about fifty years ago, when there were no science teachers and no laboratories in girls' schools and no body of women scientists. Much progress has been made but physics is the branch of science which has been the last to be taught in the girls' schools, and there is still need for a good deal of work before satisfactory and consistent standards are reached. To increase the number of women physicists in the near future this work will have to be faced immediately.

Rutherford Lecture of The Physical Society

Members of the Institute are invited to attend the 1958 Rutherford Lecture which is to be given by Professor Niels Bohr on "General Implications of the Discovery of the Atomic Nucleus." The meeting will be held in the large lecture theatre of the Chemistry Department of Imperial College of Science and Technology, London, at 5 p.m., on Friday, November 28.

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The Third Pugwash Conference—September, 1958

By Professor DAME KATHLEEN LONSDALE, D.B.E., D.Sc., F.R.S.

(*University College, London*)

FOLLOWING immediately after the Second International Conference on the Peaceful Uses of Atomic Energy at Geneva, a group of scientists from nineteen countries met first at Kitzbühel and then in Vienna, by invitation of Lord (Bertrand) Russell and through the generosity of the Koerner Foundation, the Federal President of Austria and the Municipality of Vienna, to discuss the social and political implications of nuclear science. Most of them were asked personally : only the Soviet scientists came by invitation directed to the Moscow Academy of Sciences as a body. The group from Britain were Sir George Thomson, Lord Boyd Orr, Professors C. F. Powell, M. H. L. Pryce, J. Rotblat and the writer ; Dr. Brock Chisholm and Sir Robert Watson-Watt came from Canada ; Professor M. L. E. Oliphant from Australia ; Sir Kariamannikam Krishnan and Professor P. C. Mahalanobis from India. France was represented by Father Daniel DuBarle, Drs. B. Gregory and J. Gueron, and Professor A. Lacassagne ; W. Germany by Professors Max Born, G. Burkhardt, H. Hönl, W. Kliefoth and H. Lenz ; Italy by Professors E. Amaldi (now President of I.U.P.A.P.) and E. Boeri ; Japan by Professors I. Ogawa, S. Tomonaga, Y. Miyake and S. Sakata ; The Netherlands, Denmark and Norway by Professors B. R. A. Nijboer, M. Pihl and Dr. G. Randers respectively. There was a very strong group of 20 from the U.S.A., including Dr. A. Weinberg, head of the Oak Ridge Laboratory, Professor Linus Pauling, to whom Sir Robert Watson-Watt apologized on behalf of all the British there for his cavalier treatment by our immigration officials, E. Rabinowitch, F. Seitz, V. Weisskopf, E. Wigner and H. J. Muller. Professor G. Rienäcker came from E. Germany, L. Janossy from Hungary, L. Infeld from Poland, P. Savic from Yugoslavia ; Drs. V. Knapp and J. Kozesnik from Czechoslovakia. The Soviet group included four Academicians, A. V. Topchiev, N. N. Bogolubov, D. V. Skobeltzyn and A. P. Vinagradov, and six other very distinguished scientists. A representative of The People's Republic of China received and accepted an invitation to come but at the last moment was unable to do so.

Altogether there were 67 participants, together with a number of observers, guests, wives, secretarial staff and interpreters (English-Russian only). Among the guests were one member of the British Shadow Cabinet and two American business men who had contributed generously to the travel expenses of the Conference.

Our host country, Austria, was represented at Kitzbühel only by Professor Hans Thirring, veteran physicist and educationalist, but we subsequently met a large number of Austrian Academicians at the Academy of Sciences in Vienna. Among the speakers at this formal meeting were the Federal President, Earl (Bertrand) Russell and Mr. Cyrus Eaton, the Canadian-born American who had previously financed two similar, but smaller meetings held respectively at Pugwash, Nova Scotia (July, 1957—hence the name of the series of conferences) and at Lac Beauport, Quebec (April, 1958). A huge public meeting of 7,000 people in the Vienna City Hall closed the proceedings. This was presided over by the Lord Mayor and addressed by Lord Boyd Orr, Thirring, Lacassagne, Infeld, Muller, Topchiev, Skobeltzyn, Watson-Watt ; and also by Dr. H. J. Bhabha and by Professor Hideki Yugawa, who were only able to come for the Vienna meetings.

The Kitzbühel Conference was private, but it finally issued the Statement which is printed below and which was agreed to by 65 of those present, that is by all but two (who are not named here and who refrained from voting). It was felt that such a degree of unanimity was remarkable, and it was in fact achieved by adopting in many places a wording which represented the most moderate of all opinions expressed. Looked at if only from that point of view the Statement itself is a noteworthy one and deserving of the closest attention by scientists and politicians alike. It may contain some apparent platitudes and it is long. That was essential for proper completeness. No summary could have done justice to the careful discussions which preceded its adoption.

If the Statement were to be summarized, however, it would be in terms of the absolute necessity of avoiding all future wars : not just nuclear wars, for any major war could develop into a nuclear

war, whatever controls had been applied in peacetime : not just major wars, for any minor war might develop into a major one. Not one scientist there could visualize any adequate means of defence against nuclear weapons. Scientists differ, as other men do, on the means of achieving the avoidance of war, because the means proposed involve moral and political decisions and such decisions are influenced by temperament, upbringing and nationality. But a scientific training does permit men to discuss major differences of opinion without offence and to sift out facts from opinions.

Of course those present were aware that in the field of politics the scientific method works under a major disadvantage. All the facts are never known, and yet decisions have to be made and action taken, the results of which may be irrevocable. But as far as the scientific facts *can* be known, it is the duty of scientists to make sure that they *are* known and known correctly.

Indeed, in these days of deep public distrust of all official statements, there may well be a continuing need for unofficial groups of scientists of good standing to meet informally and to hammer out the facts in politically important fields, and then to make their conclusions as widely known as possible. One point that was particularly emphasized by Hans Thirring was that if nations took really seriously the absolute need to avoid all wars, this would revolutionize our systems of education. The fact that education has not yet been revolutionized by any nation is a measure of national apathy or unawareness of the real needs of the times.

It was natural also that the need for industrialization of the technically under-developed nations should have been emphasized by the members from India. The much-desired achievement of international disarmament, dependent partly upon controls, but much more upon the gradual establishment of a climate of mutual trust, through deeds and not declarations, would release money, materials and manpower for help to needy peoples. This is known theoretically, but the " lions in the way " have so far discouraged more than the first tentative steps in the direction of disarmament.

The following is the Statement signed by 65 delegates, including all those whose names are quoted above :—

1—NECESSITY TO END WARS

We meet in Kitzbühel and in Vienna at a time when it has become evident that the development of nuclear weapons makes it possible for man to destroy civilization and, indeed, himself ; the means of destruction are being made ever more efficient. The scientists attending our meetings have long been concerned with this development, and they are unanimous in the opinion that a full-scale nuclear war would be a world-wide catastrophe of unprecedented magnitude.

In our opinion defence against nuclear attack is very difficult. Unfounded faith in defensive measures may even contribute to an outbreak of war.

Although the nations may agree to eliminate nuclear weapons and other weapons of mass destruction from the arsenals of the world, the knowledge of how to produce such weapons can never be destroyed. They remain for all time a potential threat for mankind. In any future major war, each belligerent state will feel not only free but compelled to undertake immediate production of nuclear weapons ; for no state, when at war, can be sure that such steps are not being taken by the enemy. We believe that, in such a situation, a major industrial power would require less than one year to begin accumulating atomic weapons. From then on, the only restraint against their employment in war would be agreements not to use them, which were concluded in times of peace. The decisive power of nuclear weapons, however, would make the temptation to use them almost irresistible, particularly to leaders who are facing defeat. It appears therefore that atomic weapons are likely to be employed in any future major war, with all their terrible consequences.

It is sometimes suggested that localized wars, with limited objective, might still be fought without catastrophic consequences. History shows, however, that the risk of local conflicts growing into major wars is too great to be acceptable in the age of weapons of mass destruction. Mankind must therefore set itself the task of eliminating all wars, including local wars.

2—REQUIREMENTS FOR ENDING THE ARMS RACE

The armaments race is the result of distrust between states ; it also contributes to this distrust. Any step that mitigates the arms race, and leads to even small reductions in armaments and armed forces, on an equitable basis and subject to necessary control, is therefore desirable.

We welcome all steps in this direction and, in particular, the recent agreement in Geneva between representatives of East and West about the feasibility of detecting test-explosions. As scientists, we take particular pleasure in the fact that this unanimous agreement, the first after a long series of unsuccessful international disarmament negotiations, was made possible by mutual understanding and a common objective approach by scientists from different countries. We note with satisfaction that the Governments of the U.S.A., U.S.S.R., and U.K. have approved the statements and the conclusion contained in the report of the technical experts. This is a significant success ; we most earnestly hope that this approval will soon be followed by an international agreement leading to the cessation of all nuclear weapon tests and an effective system of control. This would be a first step toward the relaxation of international tension and the end of the arms race.

It is generally agreed that any agreement on disarmament, and in particular nuclear disarmament, requires measures of control to protect every party from possible evasion. Through their technical competence, scientists are well aware that effective control will in some cases be relatively easy, while it is very difficult in others. For example, the conference of experts in Geneva has agreed that the cessation of bomb-tests could be monitored by a suitable network of detecting stations. On the other hand, it will be a

technical problem of great difficulty to account fully for existing stocks of nuclear weapons and other means of mass destruction. An agreement to cease production of nuclear weapons presents a problem of intermediate technical difficulty between these two extreme examples.

We recognize that the accumulation of large stocks of nuclear weapons has made a completely reliable system of controls for far-reaching nuclear disarmament extremely difficult, perhaps impossible. For this disarmament to become possible, nations may have to depend, in addition to a practical degree of technical verification, on a combination of political agreements, of successful international security arrangements, and of experience of successful co-operation in various areas. Together, these can create the climate of mutual trust which does not now exist, and an assurance that nations recognize the mutual political advantages of avoiding suspicion.

Recognizing the difficulties of the technological situation, scientists feel an obligation to impress on their peoples and on their governments the need for policies which will encourage international trust and reduce mutual apprehension. Mutual apprehensions cannot be reduced by assertions of good will ; their reduction will require political adjustment and the establishment of active co-operation.

3—WHAT WAR WOULD MEAN

Our conclusions about the possible consequences of war have been supported by reports and papers submitted to our Conference. These documents indicate that if, in a future war, a substantial proportion of the nuclear weapons already manufactured were delivered against urban targets, most centres of civilization in the belligerent countries would be totally destroyed, and most of their populations killed. This would be true whether the bombs used derived most of their power from fusion reactions (so-called " clean " bombs) or principally from fission reactions (so-called " dirty " bombs). In addition to destroying major centres of population and industry, such bombs would also wreck the economy of the country attacked, through the destruction of vital means of distribution and communication.

Major states have already accumulated large stocks of " dirty " nuclear weapons ; it appears that they are continuing to do so. From a strictly military point of view, dirty bombs have advantages in some situations ; this makes likely their use in a major war.

The local fall-out resulting from extensive use of " dirty " bombs would cause the death of a large part of the population in the country attacked. Following their explosion in large numbers (each explosion equivalent to that of millions of tons of ordinary chemical explosive), radioactive fall-out would be distributed not only over the territory to which they were delivered but, in varying intensity, over the rest of the Earth's surface. Many millions of deaths would thus be produced, not only in belligerent but also in non-belligerent countries, by the acute effects of radiation.

There would be, further, substantial long-term radiation damage, to human and other organisms everywhere, from somatic effects such as leukaemia, bone cancer, and shortening of the lifespan ; and from genetic damage affecting the hereditary traits transmitted to the progeny.

Knowledge of human genetics is not yet sufficient to allow precise predictions of consequences likely to arise from the considerable increase in the rate of mutation which would ensue from unrestricted nuclear war. However, geneticists believe that they may well be serious for the future of a surviving world population.

It is sometimes suggested that in a future war, the use of nuclear weapons might be restricted to objectives such as military bases, troop concentrations, airfields, and other communication centres ; and that attacks on large centres of population could thus be avoided.

Even tactical weapons now have a large radius of action ; cities and towns are commonly associated with centres of supply and transportation. We, therefore, believe that even a " restricted " war would lead, despite attempted limitation of targets, to widespread devastation of the territory in which it took place, and to the destruction of much of its population. Further, an agreement not to use cities for military purposes, entered into in order to justify their immunity from attack, is unlikely to be maintained to the end of a war, particularly by the losing side. The latter would also be strongly tempted to use nuclear bombs against the population centres of the enemy, in the hope of breaking his will to continue the war.

4—HAZARDS OF BOMB TESTS

At our first conference it had been agreed that while the biological hazards of bomb tests may be small compared with similar hazards to which mankind is exposed from other sources, hazards from tests exist and should receive close and continued study. Since then, an extensive investigation by the United Nations Scientific Committee on the Effects of Atomic Radiation has been carried out and its authoritative conclusions published.

In this case, too, scientists from many different countries have been able to arrive at a unanimous agreement. Their conclusions confirm that the bomb tests produce a definite hazard and that they will claim a significant number of victims in present and following generations. Though the magnitude of the genetic damage appears to be relatively small compared with that produced by natural causes, the incidence of leukaemia and bone cancer due to the radioactivity from test explosions may, in the estimate of the U.N. committee, add significantly to the natural incidence of these diseases. This conclusion depends on the assumption (not shared by all authorities in the field) that these effects can be produced even by the smallest amount of radiation. This uncertainty calls for extensive study and, in the meantime, for a prudent acceptance of the most pessimistic assumption. It lends emphasis to the generally agreed conclusion that all unnecessary exposure of mankind to radiation is undesirable and should be avoided.

It goes without saying that the biological damage from a war, in which many nuclear bombs would be used, would be incomparably larger than that from tests ; the main immediate problem before mankind is thus the establishment of conditions that would eliminate war.

5—SCIENCE AND INTERNATIONAL CO-OPERATION

We believe that, as scientists, we have an important contribution to make toward establishing trust and co-operation among nations. Science is, by long tradition, an international undertaking. Scientists with different national allegiances easily find a common basis of understanding : they use the same concepts and the same methods ; they work toward common intellectual goals, despite differences in philosophical,

economic, or political views. The rapidly growing importance of science in the affairs of mankind increases the importance of the community of understanding.

The ability of scientists all over the world to understand one another, and to work together, is an excellent instrument for bridging the gap between nations and for uniting them around common aims. We believe that working together in every field where international co-operation proves possible makes an important contribution toward establishing an appreciation of the community of nations. It can contribute to the development of the climate of mutual trust, which is necessary for the resolution of political conflicts between nations, and which is an essential background to effective disarmament. We hope scientists everywhere will recognize their responsibility, to mankind and to their own nations, to contribute thought, time, and energy to the furthering of international co-operation.

Several international scientific undertakings have already had considerable success. We mention only the century-old, world-wide co-operation in weather science, the two International Polar Years which preceded (by 75 and 25 years respectively), the present International Geophysical Year, and the Atoms-for-Peace Conferences. We earnestly hope that efforts will be made to initiate similar collaboration in other fields of study. Certainly they will have the enthusiastic support of scientists all over the world.

We call for an increase in the unrestricted flow of scientific information among nations, and for a wide exchange of scientists. We believe that nations which build their national security on secrecy of scientific developments sacrifice the interests of peace, and of the progress of science, for temporary advantages.

It is our belief that science can best serve mankind if it is free from interference by any dogma imposed from the outside, and if it exercises its right to question all postulates, including its own.

6—TECHNOLOGY IN THE SERVICE OF PEACE

In our time, pure and applied science have become increasingly interdependent. The achievements of fundamental, experimental and theoretical science are more and more rapidly transformed into new technological developments. This accelerated trend is manifest, alike in the creation of weapons of increased destructiveness, and in the development of means for the increased wealth and well-being of mankind.

We believe that the tradition of mutual understanding and of international co-operation, which have long existed in fundamental science, can and should be extended to many fields of technology. The International Atomic Energy Agency, for example, aims not merely at co-operation for establishing facts about atomic energy, but also at helping the nations of the world to develop a new source of energy as a basis for the improvement of their material welfare. We believe that international co-operation in this and other fields, such as economic development and the promotion of health, should be greatly strengthened.

The extremely low level of living in the industrially underdeveloped countries of the world is and will remain a source of international tension. We see an urgent need to forward studies and programs for the effective industrialization of these countries. This would not only improve the level of living of the majority of the population of the world ; it would also help reduce the sources of conflict between the highly industrialized powers. Such studies would offer fruitful scope for co-operative efforts between scientists of all nations.

The great increase in the ease and speed of communications, and our increasing understanding of how the forces of Nature influence the living conditions of nations in different parts of the world, show us, in a way not previously possible, the extent to which the prosperity of individual nations is connected with, and dependent upon, that of mankind as a whole ; and how rapidly it could be increased by common international effort. We believe that through such common effort the co-existence between nations of different social and economic structure can become not merely peaceful and competitive, but to an increasing degree co-operative, and therefore more stable.

As scientists, we are deeply aware of the great change in the condition of mankind which has been brought about by the modern development and application of science. Given peace, mankind stands at the beginning of a great scientific age. Science can provide mankind with an ever-increasing understanding of the forces of Nature, and the means of harnessing them. This will bring about a great increase in the wellbeing, health, and prosperity of all men.

7—THE RESPONSIBILITY OF SCIENTISTS

We believe it to be a responsibility of scientists in all countries to contribute to the education of the peoples by spreading among them a wide understanding of the dangers and potentialities offered by the unprecedented growth of science. We appeal to our colleagues everywhere to contribute to this effort, both through enlightenment of adult populations, and through education of the coming generations. In particular, education should stress improvement of all forms of human relations and should eliminate any glorification of war and violence.

Scientists are, because of their special knowledge, well equipped for early awareness of the danger and the promise arising from scientific discoveries. Hence, they have a special competence and a special responsibility in relation to the most pressing problems of our times.

In the present conditions of distrust between nations, and of the race for military supremacy which arises from it, all branches of science—physics, chemistry, biology, psychology—have become increasingly involved in military developments. In the eyes of the people of many countries, science has become associated with the development of weapons. Scientists are either admired for their contribution to national security, or damned for having brought mankind into jeopardy by their invention of weapons of mass destruction. The increasing material support which science now enjoys in many countries is mainly due to its importance, direct or indirect, to the military strength of the nation and to its degree of success in the arms race. This diverts science from its true purpose, which is to increase human knowledge, and to promote man's mastery over the forces of nature for the benefit of all.

We deplore the conditions which lead to this situation, and appeal to all peoples and their governments to establish conditions of lasting and stable peace.

Examinations for National Certificates in Applied Physics, 1958

The number of candidates entering for the Ordinary and Higher National Certificates in Applied Physics continues to increase very satisfactorily and, as will be seen from the details given below, forty-one colleges presented candidates for the Ordinary Certificate this year and twenty colleges had candidates for the Higher National Certificate. During the year several colleges have put on new courses and the number of colleges presenting candidates should increase again next year.

The certificates are awarded jointly by the Institute and the Ministry of Education or, in Scotland, the Scottish Education Department. Schemes submitted by colleges are subject to the approval of joint committees of the Institute and the Ministry or the Institute and the Department. The standard of the examination is the responsibility of the Institute and assessors are appointed for this purpose. They cannot, of course, maintain uniformity of standard but it is their function to try to ensure that no college falls below an acceptable minimum. Inevitably there is some variation ; the standard reached by some of the smaller colleges has been commented upon very favourably by the assessors.

The following Fellows were the Institute's assessors for the 1958 examinations :—

England and Wales

Physics —Professor J. D. Craggs

Applied Physics —Mr. A. E. De Barr

Mathematics —Dr. J. Crank

Scotland

All three subjects—Dr. G. Morris

Dr. Morris has now retired as the Institute's assessor for Scotland after serving for seven years, and the Board has expressed its appreciation of the services that he has given. Dr. J. M. Valentine (*Fellow*) has been appointed to succeed Dr. Morris.

Members who may be interested in the possibility of their assistants taking courses for National Certificates in Applied Physics may like to have a copy of a booklet containing selected examination papers ; the booklet is available free of charge on application to the Deputy Secretary, who will also be glad to give any further information on the courses or examinations for these certificates.

The following are the detailed results of the 1958 examinations. Of the 416 candidates who passed the examination for the Ordinary National Certificate, 164 are not entitled to the actual award of the Ordinary certificate. These candidates have completed only one year of the three-year, part-time course and are primarily intending to study for the Higher National Certificate. Nearly all of them have one or more passes at Advanced level in the General Certificate of Education and are thereby entitled to substantial exemption from the Ordinary National Certificate course.

	Ordinary National Certificate			Higher National Certificate					
							Distinctions		
College	*Candidates*	*Passes*	*Failures*	*Candidates*	*Passes*	*Failures*	*Physics*	*Applied Physics*	*Mathematics*
(*a*) ENGLAND AND WALES :									
Acton : Brunel College of Technology	—	—	—	14	11	3	3	0	2
Bedford : Mander College	17	3	14	—	—	—	—	—	—
Birmingham College of Technology ...	41	28	13	7	6	1	1	2	2
Bournemouth Municipal College of Technology and Commerce ...	8	5	3	7	5	2	0	0	0
Brighton Technical College	8	6	2	—	—	—	—	—	—
Bristol College of Technology ...	9	9	0	—	—	—	—	—	—
Cambridge : Cambridgeshire Technical College and School of Art ...	5	5	0	—	—	—	—	—	—
Cardigan Grammar School	13	5	8	—	—	—	—	—	—
Connah's Quay : Flintshire Technical College	8	3	5	—	—	—	—	—	—
Croydon Technical College	17	15	2	8	6	2	0	1	2

College	*Candidates*	*Passes*	*Failures*	*Candidates*	*Passes*	*Failures*	*Distinctions* *Physics*	*Applied Physics*	*Mathematics*
Crumlin : Technical College of Monmouthshire	10	6	4	3	2	1	0	0	0
South-East Dagenham : Essex Technical College	3	3	0	—	—	—	—	—	—
Derby and District College of Technology...	7	6	1	—	—	—	—	—	—
Ewell County Technical College ...	8	6	2	—	—	—	—	—	—
Guildford County Technical College ...	36	29	7	28	21	7	3	3	5
Harrow Technical College	12	9	3	—	—	—	—	—	—
Kettering Technical College	8	3	5	—	—	—	—	—	—
Kingston Technical College	8	8	0	—	—	—	—	—	—
Leeds College of Technology	7	6	1	8	6	2	2	0	1
Letchworth : North Herts Technical College	26	12	14	10	10	0	0	1	1
Liverpool : City of Liverpool College of Technology	14	6	8	13	9	4	0	0	2
London :									
Northampton College of Advanced Technology	33	26	7	28	16	12	2	2	0
South-East London Technical College	51	30	21	31	24	7	2	3	2
Newbury : South Berkshire College of Further Education	48	31	17	—	—	—	—	—	—
Oxford College of Technology, Art and Commerce	22	13	9	8	5	3	0	0	0
Preston : Harris College of Further Education	15	8	7	5	4	1	1	0	1
Reading Technical College	37	28	9	13	8	5	0	0	3
Rotherham College of Technology ...	11	8	3	4	4	0	3	0	0
Rugby College of Technology and Arts	16	11	5	—	—	—	—	—	—
Salford Royal Technical College ...	23	16	7	19	13	6	1	1	0
Salisbury and South Wilts. College of Further Education	6	5	1	—	—	—	—	—	—
Southend-on-Sea Municipal College ...	27	10	17	5	3	2	0	0	0
Stoke-on-Trent : North Staffordshire Technical College	6	6	0	—	—	—	—	—	—
Sunderland Technical College ...	21	13	8	11	8	3	0	1	1
Swansea Technical College	12	7	5	11	8	3	4	1	3
Weybridge : Brooklands County Technical College	7	7	0	—	—	—	—	—	—
Whitehaven College of Further Education	8	5	3	—	—	—	—	—	—
Wolverhampton and Staffordshire College of Technology	5	3	2	—	—	—	—	—	—
Worcester : Victoria Institute ...	5	5	0	—	—	—	—	—	—
TOTAL	618 [38 Colleges]	405	213	233	169 [19 Colleges]	64	22	15	25

College	*Candidates*	*Passes*	*Failures*	*Candidates*	*Passes*	*Failures*	*Distinctions Physics*	*Distinctions Applied Physics*	*Distinctions Mathematics*
(*b*) SCOTLAND :									
Aberdeen: Robert Gordon's Technical College	3	3	0	—	—	—	—	—	—
Dundee Technical College	5	2	3	—	—	—	—	—	—
Paisley Technical College	11	6	5*	13	6†	7*	0	0	0
TOTAL	19	11	8	13	6	7	0	0	0
	[3 Colleges]								
	* includes one candidate referred in one subject			† includes one candidate awarded certificate after being referred in one subject in 1957 * includes one candidate referred in one subject					
GRAND TOTAL ...	637	416	221	246	175	71	22	15	25
	[41 Colleges]			[20 Colleges]					

Forthcoming Institute Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
Nov. 13	**Liverpool** The University	Four speakers from industry	Discussion on **The physicist in industry**	4.00 p.m.	Liverpool and North Wales
Nov. 14	**London** The Institute's House		**Group Annual General Meeting. Papers on the Spectroscopy of high temperature plasma**	To be announced	Applied Spectroscopy
Nov. 14	**Manchester** College of Science and Technology	Dr. L. R. G. Treloar, F.Inst.P. (*British Rayon Research Association*)	**The photoelastic properties of polymers**	6.45 p.m.	Non-Destructive Testing—Jointly with Manchester and District
Nov. 14	**Cardiff** University College	Dr. J. W. Mitchell, F.R.S. (*University of Bristol*)	**Photographic sensitivity**	5.15 p.m.	South Wales
Nov. 14	**Cheltenham** N. Gloucestershire Technical College	Mr. E. W. H. Selwyn, F.R.P.S., F.Inst.P. (*Kodak Limited, Harrow*)	**Definition in photographs**	7.00 p.m.	South Western
Nov. 18	**London** The Institute's House	Dr. M. H. Oliver, (*Royal Radar Establishment, Malvern*)	**Masers**	5.30 p.m.	Electronics
Nov. 19	**London** The Institute's House	Dr. K. A. G. Mendelssohn, F.Inst.P., F.R.S. (*Clarendon Laboratory, University of Oxford*)	**Planck and his work—Celebration of the centenary of the birth of Max Planck**	6.00 p.m.	Education
Nov. 21	**Glasgow** The University	Dr. S. C. Curran, F.R.S. (*Atomic Weapons Research Establishment, Aldermaston*)	**Controlled thermonuclear work**	7.15 p.m.	Scottish

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
Nov. 24	**Edinburgh** The University	Dr. S. C. Curran, F.R.S. (*Atomic Weapons Research Establishment, Aldermaston*)	**Controlled thermo-nuclear work**	7.15 p.m.	Scottish
Nov. 25	**Birmingham** Exchange and Engineering Centre	Dr. R. E. Bastick A.Inst.P. (*Chance Brothers Ltd., Smethwick*)	**Branch Annual General Meeting. Chairman's address—Some applications of glass in the field of atomic energy**	7.00 p.m.	Midland
Nov. 26	**Sheffield** The University	Dr. B. J. Mason (*Imperial College of Science and Technology, London*)	**Recent developments in the physics of rain and rain making**	5.15 p.m.	Yorkshire
Nov. 27	**London** Royal Society of Arts		**Group Annual General Meeting and all-day meeting**	—	Electron Microscopy
			Electron Staining : Reviews on papers presented at the International Conference on Electron Microscopy (Berlin, Sept. 1958)	To be announced	
Nov. 28	**London** Institution of Civil Engineers		**Autumn Conference Precipitation in alloys**	10.00 a.m. 5.00 p.m.	X-Ray Analysis —Jointly with Electron Microscopy
Nov. 29	**London** Institution of Civil Engineers		**Autumn Conference** (continued) **Metals**	9.30 a.m.- 12.30 p.m.	X-Ray Analysis
Dec. 1	**Edinburgh** The University	Dr. B. Meltzer (*University of Edinburgh*)	**Dense electron beams**	7.15 p.m.	Scottish
Dec. 2	**Glasgow** The University	Dr. B. Meltzer (*University of Edinburgh*)	**Dense electron beams**	7.15 p.m.	Scottish
Dec. 3	**London** The Institute's House	Prof. H. Hartridge, F.R.S.	**Transparency projection**	6.00 p.m.	Education
Dec. 3	**London**	(*see page 282*)		5.00 p.m.	Applied Spectroscopy
Dec. 8	**Glasgow** The University	Mr. A. D. Le Claire (*U.K. Atomic Energy Authority, Harwell*)	To be announced	7.15 p.m.	Scottish
Dec. 9	**Aberdeen** The University	Mr. A. D. Le Claire (*U.K. Atomic Energy Authority, Harwell*)	To be announced	7.30 p.m.	Scottish
Dec. 11	**Liverpool** The University	Mr. R. S. Pease (*U.K. Atomic Energy Authority, Harwell*)	**Thermonuclear power**	7.00 p.m.	Liverpool and North Wales
Dec. 11	**London** The Institute's House	Dr. G. D. Robinson, F.Inst.P. (*Meteorological Office, Air Ministry, London*)	**Exploring the vertical structure of the atmosphere**	6.00 p.m.	London and Home Counties
Dec. 11	**Birmingham** Imperial Chemical Industries Limited	Dr. T. W. Farthing (*New Metals Section, I.C.I. Research Department, Metals Division, Witton, Birmingham*)	**Visit to the Metals Division of Imperial Chemical Industries Ltd. followed by Lecture on New metals** (numbers limited)	2.30 p.m.	Midland

Date	Place	Speaker	Title	Time	Branch or Group
Dec. 11	**Middlesbrough** Cleveland Scientific and Technical Institution	Dr. A. W. Brewer, F.Inst.P. (*Clarendon Laboratory, University of Oxford*)	**Instruments used in the exploration of the stratosphere**	6.00 p.m.	North Eastern—Jointly with Society of Instrument Technology
Dec. 12	**London** The Institute's House	Dr. J. Krautkramer (*J. & H. Krautkramer, Cologne*)	**Ultrasonic developments**	6.00 p.m.	Non-Destructive Testing
Dec. 12	**Swansea** University College	Dr. W. Walkinshaw (*U.K. Atomic Energy Authority, Harwell*)	**Branch Annual General Meeting. High energy particle accelerators**	5.15 p.m.	South Wales
Dec. 12	**Bristol** The University	Dr. R. M. Payne (*Associated Electrical Industries Research Laboratory, Aldermaston*)	**The quest for controlled thermonuclear reactors**	7.00 p.m.	South Western

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON OCTOBER 7, 1958

An asterisk (*) indicates transfer from another grade

FELLOWS

Calderwood, James Henry, M.Eng., Ph.D., Head of Electrical Engineering Department, Royal Technical College, Salford, Lancs.

*Faust, Roy Claude, M.Sc., Ph.D., Senior Technical Officer, British Nylon Spinners Ltd., Pontypool, Mon.

*Jones, Harold Goulbourne, M.A., M.Sc., Head of Laboratories, U.K. Atomic Energy Authority, Dounreay Experimental Reactor Establishment, Caithness.

Tottle, Charles Ronald, M.Met., Deputy Director—Head of Reactor Division, U.K. Atomic Energy Authority, Dounreay Experimental Reactor Establishment, Caithness.

*Tucker, Malcolm John, B.Sc., Principal Scientific Officer, National Institute of Oceanography, Godalming, Surrey.

*Tyler, Thomas Harold, B.Sc., Lecturer in Physics, The Polytechnic, Regent Street, London.

ASSOCIATES

Anand, Vidya Bhushan, B.A., M.Sc., Principal and Professor of Physics, Bhargava Municipal College, Simla, India.

Anderson, Richard Austin, B.Sc., Ph.D., Lecturer, University of Western Australia.

Ashworth, Francis Paul Oswald, M.Sc., Group Leader, Fairey Aviation Co. Ltd., Hounslow, Middlesex.

*Atherton, Arthur, B.Sc., Research Student, University of Sheffield.

*Bean, Leonard William, B.Sc., Scientific Staff, The General Electric Co. Ltd., Wembley, Middlesex.

Beckmann, Peter Eberhard, Dr.rer.nat., British Council Scholar, Department of Mathematics, University College of North Staffordshire, Keele, Staffs.

Birss, Robert Raymond, B.Sc., Ph.D., Assistant Lecturer, University of Nottingham.

Bowe, Pierce William Arnott, M.Sc., Ph.D., Senior Scientific Officer, Department of Supply, Weapons Research Establishment, Australia.

Bradley, Edward Michael, B.Sc., Physics Group Leader, British Tabulating Machine Co. Ltd., Stevenage, Herts.

Clarke, Frederick James Patrick, B.Sc., Ph.D., Senior Scientific Officer, Atomic Energy Research Establishment, Harwell, Berks.

*Clarke, John Owen, B.Sc., Ph.D., Scientific Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Cutress, John Oliver, B.Sc., Ph.D., Physicist, National Coal Board, Newcastle-on-Tyne, Durham.

*Doram, Colin Carrington, B.Sc., Assistant Lecturer, Medway College of Technology, Chatham, Kent.

Draper, Laurence, M.Sc., Experimental Officer, National Institute of Oceanography, Wormley, Surrey.

Edmundson, Maurice, B.Sc., Head of Science Department, Plaistow Grammar School, London

Exelby, Richard, M.A., Assistant Lecturer, Leicester College of Technology.

Fidleris, Vilius, B.Sc., Ph.D., Scientist, National Coal Board, Cheltenham, Glos.

*Followell, Roy Frederick, B.Sc., Ph.D., Physicist, Courtaulds Ltd., Coventry.

Francis, Dennis, B.Sc., Assistant Lecturer, Birmingham College of Technology.

*Fromberg, Cyril, B.Sc., Senior Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

*Glaister, Raymond Malcolm, B.Sc., Ph.D., Senior Physicist, G.V. Plaver Ltd., Sunbury-on-Thames, Middlesex.

Gunn, William Frazer, B.Sc., Principal Scientific Officer, U.K. Atomic Energy Authority, Aldermaston, Berks.

Hands, Peter Edward, B.Sc., Senior Lecturer, Perth Technical College, Western Australia.

Howes, David, B.Sc., Physicist, Chance Bros. Ltd., Smethwick, Staffs.

*Isaac, Philip John, B.Sc., Assistant Master, Liverpool Institute High School for Boys.

Lowry, William Sidney Blair, B.Sc., Physicist, City of Dublin Skin and Cancer Hospital, Ireland.

*Marlow, Peter Frederic, B.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool, Mon.

*Matthews, Aubrey Royston, B.Sc., Ph.D., Junior Reservoir Engineer, Shell Petroleum Co. Ltd., Venezuela.

Pascoe, Michael William, B.A., Ph.D., Technical Officer, British Nylon Spinners Ltd., Pontypool, Mon.

Pritchard, Gwilym Owen, B.Sc., Assistant Lecturer, Denbighshire Technical College, Wrexham.

Parvataneni, Tiruvenganna Rao, D.Sc., Reader, University of Andhra, India.

*Richards, Harold John, M.Sc., Physicist, Printing, Packaging and Allied Trades Research Association, Leatherhead, Surrey.

Robinson, Herbert Gordon, B.Sc., A.R.C.S., Senior Physics Master, Westcliff High School for Boys, Essex.

*Sewell, Peter Broun, B.Sc., Temporary Lecturer, University of Western Australia.

*Shewring, Donald, B.Sc., Senior Research Physicist, Richard Thomas and Baldwins Ltd., Aylesbury, Bucks.

*Showell, John Martin, B.Sc., Technical Officer, Marston Excelsior Ltd., Wolverhampton.

*Smith, Raymond Augustus, B.Sc., Lecturer, Enfield Technical College, Middlesex.

Stone, Reginald Noel, B.Sc., Research Physicist, The General Electric Co. Ltd., Wembley, Middlesex.

*Solntseff, Nicholas, B.Sc., Ph.D., Teaching Fellow, University of Sydney.

Thomson, William, B.Sc., Senior Scientific Officer, U.K. Atomic Energy Authority, Springfield, Preston, Lancs.

*Townsend, William Godfrey, B.Sc., Ph.D., Lecturer, University College of Swansea.

*Wilcox, Ronald John, B.Sc., Technical Officer, Imperial Chemical Industries Ltd., Birmingham.

*Wootten, Norman Wilfred, B.Sc., Experimenta, Officer, Chemical Defence Experimental Est.l Porton Down, Wiltshire.

GRADUATES

Abbott, David Glyn, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Cumberland.

Addley, John Ambrose, B.Sc., Senior Research Physicist, Powers-Samas Accounting Machines Ltd., Surrey.

Arnell, Robert Derek, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Culcheth, Warrington, Lancs.

Avient, Brian William Edward, M.Sc., Research Student, Imperial College, London.

Baker, Harry, B.A., Investigator, Aluminium Laboratories Ltd., Banbury, Oxon.

Branston, Neil Mark, B.Sc., Senior Scientific Officer, The General Electric Co. Ltd., Stanmore, Middlesex.

Brebner, Raymond Ian, B.Sc., Experimental Officer, Admiralty Materials Laboratory, Holton Heath, Dorset.

Buckingham, Herbert Charles, B.Sc., Glass Technologist, Chance Bros. Ltd., Smethwick, Birmingham.

Clayton, David Brewster, B.Sc., Research Officer, G.K.N. Group Research Laboratory, Wolverhampton.

Cripps, Henry, B.Sc., Laboratory Assistant, Courtaulds Ltd., Manchester.

*Davison, Sydney George, B.Sc., Assistant Physics Master, Salford Grammar School, Lancs.

Dench, Paul Charles, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

*Dobing, Edward, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Cumberland.

*Easson, Douglas Roy, Assistant Experimental Officer, Royal Aircraft Establishment, Bedford.

Fairbairn, Peter, B.Sc., Physicist, C. A. Parsons & Co. Ltd., Heaton Works, Newcastle-on-Tyne.

Ferer, Harman Gerald, B.Sc., Research Physicist, Vickers Armstrong Aircraft Ltd., Swindon, Wilts.

Firk, Frank William Kenneth, B.Sc., Experimental Officer, Atomic Energy Research Establishment, Aldermaston, Berks.

Froud, Gerald Roy, Assistant Experimental Officer, Armament Research Establishment, London.

*Gallagher, Noel Thomas, B.Sc., Research Physicist, G.V. Planer Ltd., Sunbury-on-Thames, Middlesex.

Gibson, John Anthony Beresford, B.Sc., Scientific Officer, Atomic Energy Research Establishment, Harwell.

Green, Oliver George, Research Assistant, Northampton College of Advanced Technology, London.

*Griffiths, Anthony, B.Sc., Research Student, University of Reading.

Heppell, Thomas Alexander, B.Sc., Physicist, Edwards High Vacuum Ltd., London.

Herron, Joseph Bryan, B.Sc., Development Engineer, Fairy Aviation Co. Ltd., Heston Airport, Middlesex.

Hodgson, John Arthur, B.Sc., Schoolmaster, Arnold School, Blackpool, Lancs.

*Horler, Dennis Leon, B.Sc., Radio Telephone Engineer, Standard Telephones and Cables Ltd., London.

James, Frederick David, B.Sc., Assistant Engineer, Smith's Aircraft Instruments Ltd., Bishop's Cleeve, Cheltenham, Glos.

Jones, Dorothy Elizabeth, B.Sc., Physicist, British Hat and Allied Feltmakers Research Association, Droylsden, Manchester.

*Kendall, Ernest John Michael, B.Sc., Research Student, University of Birmingham.

*Lawson, George Stuart, Assistant Experimental Officer, Mechanical Engineering Research Organization, Glasgow.

Lewis, David John Lloyd, B.Sc., Experimental Engineer, British Nylon Spinners Ltd., Pontypool, Mon.

McLaughlin, Ronald Henry, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

*McDonagh, Kevin Patrick, Technical Assistant, Ferranti Ltd., Moston, Manchester.

Malcolm, David Howard, B.Sc., Technician, A. V. Roe and Co. Ltd., Cheshire.

Marsden, Dennis, B.Sc., Assistant Experimental Officer, British Coke Research Associtaion, Sheffield.

Maycock, Geoffrey, B.Sc., Scientist, Medical Research Council.

Moore, William Stanley, B.A., Research Student, University of Nottingham.

Morgan, Francis Vincent, B.Sc., Student, Department of Education, University of Cambridge.

O'Shaughnessy, James Joseph, Experimental Officer, Royal Radar Establishment, Great Malvern, Worcs.

Patrick, Ronald, B.Sc., Assistant, East Ham Technical College, London.

Pearson, Frank Keith, B.Sc., Physicist, Baldwin and Francis Ltd., Sheffield.

Pearson, John Edward, B.Sc., Junior Physicist, Electric and Musical Industries Electronics Ltd., Middlesex.

Perrin, Stewart Reginald, B.Sc., Junior Engineer, De Havilland Propellers Ltd., Hatfield, Herts.

Phillips, Brian Gwynne, B.Sc., Engineer, De Havilland Propellers Ltd., Stevenage, Herts.

Plummer, John, Laboratory Assistant, Negretti and Zambra Ltd., London.

Ponder, Allen Charles, B.Sc., Development Engineer, Elliott Bros. (London) Ltd., London.

Pryzbylski, Josef, B.Sc., Research Student, West Ham College of Technology, London.

Ribbans, James, B.Sc., Assistant Lecturer, County Technical College, Guildford, Surrey.

Robson, Frederick Dalziel, B.Sc., Postgraduate Student, University of Southampton.

*Rowan, John O'Donnell, Senior Physics Laboratory Technician, University of Glasgow.

Sawdy, Jean Margaret, B.Sc., Assistant Experimental Officer, Atomic Weapons Research Establishment, Foulness, Essex.

Shotton, Haydn Trevor, Technical Assistant, Dunlop Rubber Co. Ltd., Birmingham.

Simpson, John Wyllie, B.Sc., Assistant Lecturer, County Technical College, Guildford, Surrey.

Smith, Michael John Arthur, B.Sc., Research Student, University of Southampton.

*Smith, Peter Anthony, B.Sc., Assistant Experimental Officer, Radio Research Station, Slough, Bucks.

Spencer, Colin Wilfred George, B.Sc., Assistant, College of Commerce and Technology, Sheffield.

Stanley, Michael William, B.Sc., Research Student, Battersea College of Technology, London.

Storey, Richard Michael, B.Sc., Experimental Officer, Department of Scientific and Industrial Research, Hull.

Street, Alec Donald, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Switzer, Benjamin George, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Tebboth, Hubert Roy, B.Sc., Demonstrator, Royal Aircraft Establishment Technical College, Farnborough, Hants.

Thomas, Hugh Protheroe, B.Sc., Physics Master, Tapston House School, Chesterfield.

Tomkins, Dennis Everett, B.Sc., Junior Electronics Engineer, The British Thomson Houston Co. Ltd., Warwicks.

West, Norman Allan, B.Sc., Graduate Apprentice, British Insulated Callenders Cables Ltd., Prescot, Lancs.

Wilkins, Ian Clive, B.Sc., Research Scientist, British Petroleum Co. Ltd.

Williams, Alexander, B.Sc., Senior Electronic Engineer, Southern Instrument Ltd., Camberley, Surrey.

Willis, John Bernard, Technical Assistant, Associated Electrical Industries Ltd., Aldermaston, Berks.

Winspear, Ronald Francis, Physicist, Chance Bros. Ltd., Birmingham.

Thirty-eight Students and four Subscribers were also elected.

The Institute's Journals

PRINCIPAL CONTENTS OF THE NOVEMBER, 1958, ISSUES

Journal of Scientific Instruments: Volume 35, No. 11

Soft X-ray spectroscopy using an electron multiplier. By J. A. Catterall, L. F. Wilson and J. Trotter.

The modification to a soft X-ray spectrograph in order to use an electron multiplier instead of a photographic plate is described. The instrument has been calibrated with the aluminium and magnesium L_{23} spectra.

A method of maintaining temperature control over a wide range. By H. L. Allsopp and D. F. Gibbs, A.Inst.P.

It is sometimes desirable to control the temperature in an apparatus without having to use a bath of stirred liquid as a means of maintaining thermal equilibrium. The apparatus described is applicable to such cases, thermal equilibrium being maintained by a stream of gas that is brought to the required temperature in a heat exchanger. The system is effective in the range −150 to 200°C, and the temperature stability varies from about ±1°C in the range 20 to 200°C to ±5°C below −110°C.

A cryostat for reactor irradiations in liquid nitrogen. By M. W. Thompson and D. W. Jefferson-Loveday.

A liquid nitrogen cryostat which has operated inside the BEPO reactor at Harwell is described. Provision was made for removing irradiated specimens in liquid nitrogen after periods of up to one month. Some difficulties encountered and the methods used to overcome them are discussed.

A variable radio-frequency inductance for the Birmingham proton synchrotron. By P. H. Rose.

An inductance capable of varying from 26 to 0·033 μH is described. The variation is achieved by saturating a ferroxcube core in a coaxial cavity by means of a large biasing current passing down the centre of the inner conductor of the cavity.

The inductance is used to tune the Cee of the Birmingham proton synchrotron over the frequency range 0·3–9·6 Mc/s. It is operated at a power level up to 40 kVA. The method and circuits by which the bias current is controlled to give the desired inductance at any frequency are also explained.

A differential thermal analysis apparatus. By F. W. Wilburn.

An automatic differential thermal analysis apparatus of high sensitivity is described in detail. The rate of heating is servo-controlled to give any selected value from 6 to 20°C per minute. Curves are obtained directly on an *X-Y* potentiometric recorder. Tem-

perature differences can be detected to within 0·1°C. Reference is made to the application of the apparatus in the study of glass-making reactions.

The effect of variations in ambient temperature upon the optical alinement of an X-ray fluorescence spectrometer. By T. A. Davies, Grad.Inst.P.

During proving tests made on an X-ray fluorescence spectrometer, it was found that variations in ambient temperature produced a significant effect upon the dispersion of the instrument. Experimental evidence indicated that this was due to changes in the interplanar spacing of the diffracting crystal. The magnitude of the effect is shown to be in good agreement with theoretical considerations.
Since the angular dispersion is an inverse function of $d \cos \theta$, the effect is most marked at high Bragg angles. The significance of the observed changes in angular dispersion, in relation to the accuracy of analysis, is pointed out.

X-ray spectrographs for rapid X-ray fluorescence analysis with photographic recording. By E. F. Priestley.

Curved crystal spectrographs are described covering the range from potassium to uranium. With the higher speed model simultaneous recording of spectra between 0·5 to 2·5Å or 1·5 to 3·75Å is possible and minor constituents at the 0·1% level can be detected. A higher sensitivity version (down to 0·001%) employs a scanning device for covering the required wavelength range. With suitable comparison standards the instruments may be used for quantitative as well as qualitative analysis.

A two co-ordinate light pointer and its application to a recording interferometer. By H. G. Kuhn and H. J. Lucas-Tooth.

A light pointer is described which allows the deflexions of two mirrors to be recorded in a two co-ordinate graph. This is used in a direct-recording Fabry-Perot interferometer for displaying the intensity as a function of air pressure.

A rotational viscometer employing a reference liquid. By J. F. Hills, A.Inst.P.

The viscometer described is a rotational one in which a free rotor is accelerated by the torque transmitted through a reference liquid by a driven rotor, and retarded by the torque acting through the liquid under test which is restrained by a stator. The free rotor thus attains an equilibrium speed of rotation. The ratio of the rates of rotation of the driven and free rotors is a linear function of the viscosity being measured, and, apart from a negligible effect of bearing friction, is independent of the absolute rotational speed of the driven rotor when using Newtonian liquids.
The theory of the viscometer is given together with an account of an experimental verification. A discussion of the practical application of the instrument includes a study of the accuracy obtainable, and it is shown that with one instrument a viscosity range of 1000 : 1 may be obtained for which the maximum error does not exceed approximately ±0·5% of the measured viscosity for a single test. For error limits of ±0·2% the range is 30 : 1.
A feature of the viscometer is that it readily lends itself to the provision of a simple digital " read-out " in any required units.

A method of correcting for the response time delays of measuring equipment. By J. A. Sirs.

The error due to the response time delay of measuring equipment on a given input waveform is obtained by considering the output response to a unit step input impulse and applying Laplace Transform analysis. Formulae are derived for correcting the error and applied to (*a*) resistance/capacitor decay curves; (*b*) the calculation of velocity constants in chemical reaction systems.

British Journal of Applied Physics: Volume 9, No. 11

The relationship between surface texture and rolling resistance of steel. By J. Halling.

The paper describes two series of experiments which were designed to investigate the relationship between the surface texture of ground mild steel surfaces and the resistance to rolling of hard steel rollers on these surfaces. In the first series of experiments the rollers were unloaded whilst in the second series of tests the rollers were subjected to a load range of 15-80 lb. In both cases it was found that the coefficient of rolling resistance increased with increasing roughness of the surface. By extrapolation of the results from the second series of tests, agreement with the results of the first series was obtained. The coefficient of rolling resistance was found to decrease with increasing load.
The variation of the coefficient of rolling resistance with load is obtained in the form of an experimental law which is compared with the various theories of the mechanism of rolling resistance.

Apparent slip between metal and rubber-covered pressure rollers. By G. J. Parish.

Measurements are described which indicate that in a roller system consisting of a metal and a rubber-covered roller rotating in contact under load, the metal roller always has the higher apparent peripheral speed whether it is driving or is driven by the rubber roller. This behaviour is similar to that observed when a wheel or cylinder is rolled over a stationary surface, and is attributed to extension of the rubber surface in the region of the nip, the extension being due in part to the contact pressure and in part to the presence of shear strains consequent on the transmission of torque through the nip. The theoretical distribution of surface strain in the rubber due to the contact pressure is derived, and the theoretical results are found to be in fair agreement with the experimental. Some further experiments designed to measure the rubber extension are described.

The measurement of the strain-dependent damping of metals vibrating torsionally. By G. Sumner and K. M. Entwistle.

Apparatus is described for the measurement at room temperature of the mechanical damping of torsionally vibrating metal specimens up to shear strains of about 2×10^{-3} for mild steel. Vibrations are maintained by a moving-coil exciter which is energized by an electronic feedback circuit and controlled by a Rochelle salt detector coupled to the end of the specimen. The phase of the exciter current is adjusted to coincide with that of the angular velocity of the specimen so that absolute values of energy loss can be obtained by measuring the exciter current, the exciter force constant and the frequency and amplitude of vibration. Values so obtained for an aluminium alloy agree with the decrement measured by a free-decay test to about 1%. Evidence is reported which shows that such agreement would not be expected with ferromagnetic specimens because the free decay tests do not allow enough time for a cyclic condition to be attained at intermediate strains. The total extraneous energy loss in the apparatus is shown to be less than 3×10^{-5} of the vibrational energy of the system.

Resonant cavity methods of measuring ferrite properties. By R. A. Waldron, A.Inst.P.

Formulae are given for the frequency shift on introducing a ferrite sample into a resonant cavity. Cylindrical rod, circular disk, and spherical samples are considered ; the sample may be placed in a region of zero electric or magnetic field, enabling magnetic and dielectric properties to be separately determined. The merits and demerits of the various sample shapes are discussed, and it is concluded that a spherical sample is usually best ; in particular, with such a sample, the dielectric constant and permeability can be measured on the same sample, in the same cavity, working in the same mode.

γ-ray yield and spectra produced by irradiating backing materials with protons. By S. E. Hunt, F.Inst.P., T. A. Pope, W. W. Evans and D. A. Hancock.

Thick targets of copper, silver, gold, tungsten, molybdenum, titanium, tantalum and tin were irradiated by protons in the energy range 0·6 to 2·8 MeV and the total γ-ray yield measured as a function of proton energy. The γ-ray spectra were also measured for a fixed proton energy of 2·2 MeV. The total γ-ray yields of the materials were found to decrease in the order given above, indicating that tungsten backings produce less total γ-ray background than any other. If high energy γ-rays are being investigated it may be advisable to use tin or gold backings since the γ-ray spectrum from these is concentrated towards the lower energies and can consequently be biased out in the counting equipment, but both materials are rather fragile under heavy proton irradiation.

Crystallographic programs for a computer. By J. C. Gower and J. H. Rayner, A.Inst.P.

A brief description is given of programs developed for the calculations involved in the X-ray analysis of crystal structures. The programs calculate three dimensional structure factors, one and two dimensional Fourier synthesis and *R*-factors.

Stresses and strains in an infinite elastic sheet under a tension applied at two rigid pairs of square jaws. By Daphne G. Padfield and Nora B. Dickinson.

First-order elastic theory of plane stresses is applied numerically to obtain estimates of the stresses in an infinite elastic sheet stretched in its own plane by forces applied at two rigid jaws. A similar method is applied (largely for purposes of comparison) to the stress in a strip tensioned by forces applied at rigid jaws extending across the whole width of the strip. As contrasted with relaxation methods, the procedure is well-suited to use with electronic computers.

The dielectric constant of zinc oxide over a range of frequencies. By N. H. Langton, A.Inst.P., and D. Matthews.

The dielectric constant of a colloidal zinc oxide has been measured by the method of mixtures, using cyclohexanol and ethyl acetate as the suspending liquids. The dielectric constant has been found to be 10·4 over the frequency range 105 kc/s to 10 Mc/s, falling to 9·4 at 25 Mc/s, measurements being made at 25°C with an accuracy of 2·3%. The dielectric constant of an acicular zinc oxide has been found to have an apparent value of about 40, over the frequency range 100 kc/s to 10 Mc/s. Results are given of dielectric constant measurements on mixtures of cyclohexanol and ethyl acetate, which appear to disobey Lichteneker's empirical logarithmic mixing rule.

The radial flow of heat in an infinite cylinder. By T. P. Newcomb, A.Inst.P.

A solution is given to the problem of heat conduction in a solid cylinder of infinite length, the surface of which is subjected to a thermal flux which decreases linearly with time. This solution may be used to determine the transient temperatures occurring at the interface or at any point within two concentric cylinders which are in contact, one of which is rotating relative to the other. The solution is of importance as it permits calculation of the temperatures reached in the lining and drum of a band brake during a brake application. Typical curves illustrating the agreement between transient temperatures determined theoretically and experimentally at the surface of the cylinder are given.

The temperature dependence of noise temperature ratio in germanium diodes. By A. Hendry.

Measurements of the 30 Mc/s noise temperature ratio of a d.c. biased germanium mixer diode at various mixer temperatures are reported. The noise temperature ratio is observed to increase as the temperature is lowered, indicating the presence of noise which is substantially in excess of thermal and shot noise, and which increases in magnitude as the temperature is lowered.

ENGLISH ELECTRIC VALVE COMPANY

CHELMSFORD, ESSEX

require experienced

ENGINEERS

for their Semi-conductor Department

(1) An engineer to take charge of a section dealing with the assessment and application of Semi-conductor Power Rectifiers. Qualifications for this post are a university degree in Electrical Engineering or corporate membership of the Institution of Electrical Engineers, and a minimum of two years experience of semi-conductors and associated circuit knowledge.

(2) An engineer for further development of Semi-conductor Rectifiers. Qualifications for this post are a Physics degree and some experience of Semi-conductor Power Rectifier design.

Applicants for the above positions should write with brief details of their experience to :— Department C.P.S., Marconi House, Strand, London, W.C.2. Quoting ref. PB1502D.

PHYSICIST

WORK ON ELECTRICAL CONTACTS

PHYSICIST OR GENERAL SCIENTIST

of graduate standard is required by an organization in S.W. Lancs., for research and development work on electrical contacts.

The work entails study of light and medium current contacts, formation of corrosion films, metallic diffusion, microphonic noise, contact resistance, etc.

This is a senior appointment in a developing department ; the successful candidate will be expected to lead the work of a small section. Encouragement for original ideas will be given, and the post offers opportunities for the candidate to become a specialist to one of the largest users of electrical contacts.

Salary offered will be commensurate with responsibility involved together with candidate's qualifications and experience. There is a generous contributory pension fund.

Please send full details of education, qualifications and experience, and approximate salary sought to the Personnel Manager, Automatic Telephone and Electric Co. Ltd., Edge Lane, Liverpool, 7.

AKERS RESEARCH LABORATORIES

Imperial Chemical Industries Ltd. has a vacancy for a graduate in mathematics, physics or chemistry, with some research experience, for the Crystallographic Laboratory at their Akers Research Laboratories, Welwyn, Herts. An interest in the mathematical aspects of structure determination by X-ray methods would be an advantage. The work is concerned with novel types of organo-metallic and co-ordination compounds, and is of an academic nature with ample scope for the publication of original research. Pension and profit-sharing schemes are in operation. For married men some assistance may be given towards house purchase and temporary lodging allowances are available in certain circumstances. Applications giving brief details of qualifications and experience should be sent to Head Office Staff Department (WDAM (a)), Imperial Chemical House, Millbank, London, S.W.1.

AUSTRALIA — UNIVERSITY OF TASMANIA

LECTURER IN PHYSICS

The University invites applications for the above position. The salary scales for lecturers are Grade II £A1,450 – 60 – £1,630 and Grade I £A1,630 – 60 – £2,050. Appointment will be offered within the range for Lecturers Grade II or Grade I according to qualifications and experience.

An allowance is made towards travel and removal expenses and housing assistance is available.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in Australia and London, is November 30, 1958.

PHYSICISTS. British Nylon Spinners Ltd. invite applications from physicists for vacancies in their Research Department. New laboratories will be ready for occupation in January, 1959, when the Company's research efforts will be still further extended. Specific problems to be studied may be either of laboratory or plant type, and range from the application of the techniques of optical crystallography to the physical structure of polymers to the development on experimental plant of novel processing methods for fibres and of fibres with new physical properties. A good honours degree is essential and, while some postgraduate experience is desirable, enquiries will also be welcomed from those who have just graduated or are at present in H.M. forces ; an imaginative approach and the ability to apply fundamental principles are considered more important than any particular background. Conditions of employment are comparable with the best in the country. The Pontypool works are situated in particularly delightful countryside, and housing problems need present no insuperable difficulties to married men. Applications should be addressed to the Personnel Manager, British Nylon Spinners Ltd., Pontypool, Mon.

SOLID STATE PHYSICS

PHYSICS GRADUATE required for a materials research laboratory situated in South Northants. Suitable candidates will be invited to join groups working on (*a*) the development of devices based on semi-conducting materials, or (*b*) the measurement of the properties of semi-conducting materials as liquid hydrogen/helium temperatures. Please reply to : The Personnel Department, The Plessey Company Ltd., Caswell, Towcester, Northants, quoting reference " Solid State/4."

ACOUSTICS ENGINEER

E.M.I. INTERNATIONAL LTD., the company which is responsible for development of recording methods and equipment for world-wide use by E.M.I. (H.M.V., Columbia, etc.) at home and by E.M.I. associate companies abroad, offers a unique opportunity in its Record Engineering Development Department for an Acoustics Engineer.

The department has recently moved into spacious new laboratories at Hayes, in which work can proceed smoothly under ideal conditions. It is exceptionally well provided with modern measuring and testing equipment, much of which has been developed and made within the department.

The successful candidate would be given every opportunity to study all aspects of recording before specializing in the acoustics field.

The post involves the measurement of the acoustics of halls, studios and listening rooms at home and abroad, and the preparation of specifications for acoustic treatment thereof. It also affords opportunity for original work in the development of new methods and equipment for the evaluation of the acoustics and sound insulation of buildings.

Candidates should preferably have an honours degree in physics and an interest in acoustics, electronics and music. Attractive salary and superannuation scheme. Apply giving details of qualification, age, etc., to :—

Personnel Department, E.M.I. Ltd.,
Hayes, Middlesex

PHYSICISTS, CHEMISTS and ENGINEERS

A large electrical engineering establishment in South West Lancs., is setting up a research laboratory to study fundamental aspects of electronic logical devices. Three types of post are available :—

(*a*) Physicists or chemists for research on conduction and other effects in semi-conductors and allied materials ;

(*b*) Physicists or electronic engineers for work on fabrication of experimental electronic devices ;

(*c*) Electronic engineers for study of applications and circuital aspects of new electronic elements.

These are senior posts which will involve responsibility for leading research in particular fields. Candidates should possess high academic qualifications together with appropriate experience. Candidates not possessing such academic qualifications but who can produce evidence of outstanding research contributions in these fields would not be excluded from consideration. Salaries will be realistic, taking full account of qualifications and experience and the calibre of the work to be undertaken. Successful applicants will be required to join the Company's Pension Scheme.

Please write to Personnel Manager, Automatic Telephone and Electric Co. Ltd., Edge Lane, Liverpool, 7, giving full details of age, qualifications and experience.

G. V. PLANER, LTD., have two new vacancies for research project leaders qualified in physics or chemistry, starting salary £1,000 – £1,500 : (1) Technology Group (resistors, printed circuits, transducers), (2) Physical-Chemistry Group (semi-conductors, dielectrics). Windmill Road, Sunbury-on-Thames, Middlesex.

AUSTRALIA — UNIVERSITY OF NEW ENGLAND

RESEARCH FELLOW — PHYSICS

Applications are invited for the position of research fellow in the Department of Physics.

Salary £A1,500 × £90 – £A2,050 plus cost of living allowance. The appointment is initially for three years extendable to five years.

The research fellow will be expected to engage in a research programme on spark discharges in association with Professor J. M. Somerville. The work will involve the use of millimicrosecond pulse techniques and a good knowledge of electronics is essential.

Provision is made for the payment of travel and removal expenses. A research fellow is not eligible for superannuation.

Further information and the conditions of appointment may be obtained from the Registrar, University of New England, Armidale, N.S.W., Australia, or from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications will close, in Australia and London, on December 18, 1958.

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Research Department : To work on research in glass and glass-making processes.

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Preferred age 25-30. Honours degree in Physics. Initial appointments determined by previous experience. Opportunity exists for transfer or promotion between departments.

Apply stating age, qualification, experience and present salary to : Personnel Officer, (Graduate Recruitment), Pilkington Brothers Ltd., St. Helens, Lancashire.

PRINCIPAL SCIENTIFIC OFFICER : Ministry of Agriculture, Fisheries and Food. Pensionable post in London for man or woman at least 31 on 1.1.58 for work on nuclear problems in relation to agriculture and food. Qualifications normally 1st or 2nd class honours degree in physics, physical chemistry or biochemistry, and at least three years postgraduate or other approved experience. Candidates should be familiar with the health physics aspects of radiation and the basis on which radiation hazards are estimated. Salary scale (men) £1,450 – £2,050. Promotion prospects. Write Civil Service Commission, 30 Old Burlington Street, London, W.1, for application form, quoting S4900/58. Closing date November 27, 1958.

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

PHYSICISTS. British Nylon Spinners Ltd. invite applications from physicists for vacancies in their Research Department. New laboratories will be ready for occupation in January, 1959, when the Company's research efforts will be still further extended. Specific problems to be studied may be either of laboratory or plant type, and range from the application of the techniques of optical crystallography to the physical structure of polymers to the development on experimental plant of novel processing methods for fibres and of fibres with new physical properties. A good honours degree is essential and, while some postgraduate experience is desirable, enquiries will also be welcomed from those who have just graduated or are at present in H.M. forces ; an imaginative approach and the ability to apply fundamental principles are considered more important than any particular background. Conditions of employment are comparable with the best in the country. The Pontypool works are situated in particularly delightful countryside, and housing problems need present no insuperable difficulties to married men. Applications should be addressed to the Personnel Manager, British Nylon Spinners Ltd., Pontypool, Mon.

UNIVERSITY OF KHARTOUM

Applications are invited for Chair of Physics. Salary £S2,760 p.a. Cost of living allowance approximately £S180 p.a. Outfit allowance £S50. Family allowances : Wife—£S60 p.a., 1st child—£S90 p.a., 2nd and 3rd child—£S30 p.a. each. (£S1 = £1 0s. 6d. sterling). Passages for appointee and family on appointment, termination and annual leave. Superannuation scheme. Initial appointment five years with possible renewal. Unfurnished accommodation provided at rent up to 7½% salary.
Detailed applications (eight copies) naming three referees by December 31, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

BICC

PHYSICIST or PHYSICAL CHEMIST, or equivalent professional qualification, required for the Shepherds Bush research laboratories of British Insulated Callender's Cables Ltd., for research on dynamic mechanical properties of high polymers The candidate would join a team engaged on the study of fundamental electrical and mechanical properties of synthetic polymers. Some experience of high polymers would be preferable but is not essential. Age up to 30 years ; five-day week ; pension fund. Applications giving details of age, qualifications and experience should be made to the Personnel Officer, B.I.C.C. Ltd., 38 Wood Lane, London, W.12.

SENIOR SCIENTIFIC INVESTIGATOR urgently needed for the International Flame Research project at Ijmuiden in Holland with the likelihood of becoming Principal Investigator to the project in two years' time. A graduate physicist, chemist, chemical engineer, fuel technologist, or mechanical engineer with postgraduate research experience equivalent to a Ph.D. and at least some knowledge of the problems of either measurements in large industrial flames or the laws of soot formation, luminous radiation and heat transfer from flames. A house or flat can be found close to the Royal Dutch Steelworks at Ijmuiden, the cost of moving to Holland would be paid, and salary in the range £1,000 to £1,500 per year. This position offers a very attractive possibility to a man wishing to establish an international reputation in the field of large flame problems.
Written applications should be sent to Professor M. W. Thring, University of Sheffield, St. George's Square, Sheffield, 1.

THE UNIVERSITY OF SHEFFIELD

Applications are invited for a Post-Doctoral Research Fellowship in the Department of Fuel Technology and Chemical Engineering. The Fellow will be required to direct and carry out research on the laws of smoke formation and elimination with all types of fuel. Initial salary £800 a year, with F.S.S.U. provision. Further particulars may be obtained from the Registrar to whom applications should be sent by December 15, 1958.

MICROWAVE MATERIALS

PHYSICISTS and RESEARCH ENGINEERS are required to join a group studying the basic and applied scientific aspects of both absorbent and transparent materials in the microwave region of the spectrum. There are also opportunities for suitable candidates to assist in progressing new developments into pilot production. The location is an applied research establishment situated in a country district in South Northants. Please reply to : The Personnel Department, The Plessey Company Ltd., Caswell, Towcester, Northants, quoting reference " Microwave/4."

PLESSEY NUCLEONICS LTD.

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LABORATORY TECHNICIAN

A laboratory technician with two to five years' experience on development of radiation detectors for the nuclear energy industry, should investigate an opportunity with this Company. We have a vacancy for which a knowledge of Light Engineering and general physics laboratory practice, including high vacuum techniques, is desirable. Construction and evaluation of new types of detector, and the development of new techniques of construction are also involved. H.N.C. (min.). Good working conditions. Canteen facilities. Pension Scheme. Salary will please successful applicant. Write Personnel Dept. (L.T.) Plessey Nucleonics Ltd., Weedon Road, Northampton.

The Nelson Research Laboratories of The English Electric Co., Ltd.

FRICTION AND SOLID STATE PHYSICS

Excellent opportunities are available for physicists and engineers with an interest in physics for the following interesting work:

(*a*) Investigations into the wear and friction characteristics of rubbing surfaces on a fundamental basis.

(*b*) Research on various aspects of solid state physics including fundamental work on magnetism and semi-conductor materials.

Previous experience in these fields is not essential but a sound basic knowledge is required.

HEAT TRANSFER

The following fields are the subjects of research and research engineers and physicists are required for investigations into the many and interesting problems in heat transfer and other aspects of mechanical engineering which they present.

THERMONUCLEAR DEVICES
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THERMOELECTRIC HEAT TRANSFER

The vacancies are of interest to mechanical engineers, electrical engineers and physicists. Graduates with relevant experience, recently qualified graduates and H.N.C. men are all needed to fill posts at appropriate levels of seniority.

The company has an attractive Staff Pension Scheme and the annual holiday after a qualifying period is three weeks.

The laboratories are situated in pleasant rural surroundings near Stafford and are rapidly expanding.

Please write giving full details of experience and qualifications to Dept., C.P.S., Marconi House, 336/7 The Strand, London, W.C.2, quoting reference PB 913K.

PLESSEY NUCLEONICS LTD.,
NORTHAMPTON

PHYSICISTS

Physicists with a degree in their subject, and tempered with two to five years' experience in research and development work are sought by this Company. They would be members of a laboratory team engaged in the application of the techniques of nuclear physics to a wide range of problems, and in research on a number of interesting projects involving the use of scintillation counters of various types. Salaries genuinely related to worth, ability and potential recognized. The special opportunities for advancement in this field are well-known, our particular conditions are good and in the first flight of springboards. Applications to Personnel Dept., Plessey Nucleonics Ltd., Weedon Road, Northampton.

UNIVERSITY OF READING

Applications are invited for a senior appointment as research physicist in the department of physics. The work will involve electrical measurements applied to the study of surface contamination processes on semiconductors. Experience in the use of ultra-high vacuum systems or in the chemical physics of surfaces is desirable. Salary according to qualifications and experience. Further particulars may be obtained from the Professor of Physics, University of Reading, Physics Research Laboratories, Upper Redlands Road, Reading, Berks., to whom applications should be submitted as soon as possible.

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEERS

Applications are invited for the appointment of assistant engineers to work in the Research Laboratories at Leatherhead, Surrey.

The selected candidates will be required to work on problems associated with conventional and nuclear power stations. Present investigations concern heat transfer in nuclear fuel elements and heat exchangers, electrostatic precipitators, cooling towers, and boiler feed pumps.

Candidates for senior vacancies should have an honours degree with previous research experience: for other vacancies a pass degree or H.N.C. with appropriate experience would be acceptable, but importance is attached to ability to apply fundamental knowledge.

The salary for these appointments will be on a scale within the range £550–£1,265 p.a., according to duties and responsibilities of the post.

Application forms obtainable from I. G. Ellis, Personnel Officer, 24-30 Holborn, London, E.C.1, should be completed and returned as soon as possible. Envelopes should be marked "Confidential—Ref: PB/352."

PHYSICIST with degree or equivalent having an interest in mechanical problems. The work will be on felting machines and include fundamental studies. Some knowledge of statistics an advantage. The post is superannuated under F.S.S.U. Age up to about 26 years.

Applications to The British Hat and Allied Feltmakers' Research Association, Stanley House, Manchester Road, Fairfield, Droylsden, Manchester.